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THE WORKS

OF

FRANCIS BACON.

Bacon, Francis, ... St. Alb. ...

THE

WORKS

OF

FRANCIS BACON,

BARON OF VERULAM, VISCOUNT ST. ALBANS, AND
LORD HIGH CHANCELLOR OF ENGLAND.

Collected and Edited

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THE

HISTORY OF LIFE AND DEATH,

OR

THE SECOND TITLE

IN

NATURAL AND EXPERIMENTAL HISTORY

FOR THE

FOUNDATION OF PHILOSOPHY:

BEING THE THIRD PART OF THE INSTAURATIO MAGNA.

TO THE PRESENT AND FUTURE AGES,

GREETING.

ALTHOUGH in my six monthly designations I placed the History of Life and Death last in order; yet the extreme profit and importance of the subject, wherein even the slightest loss of time should be accounted precious, has decided me to make an anticipation, and advance it into the second place. For it is my hope and desire that it will contribute to the common good; that through it the higher physicians will somewhat raise their thoughts, and not devote all their time to common cures, nor be honoured for necessity only: but that they will become the instruments and dispensers of God's power and mercy in prolonging and renewing the life of man, the rather because it is effected by safe, convenient, and civil, though hitherto unattempted methods. For although we Christians ever aspire and pant after the land of promise, yet meanwhile it will be a mark of God's favour if in our pilgrimage through the wilderness of this world, these our shoes and garments (I mean our frail bodies) are as little worn out as possible.

THE HISTORY OF LIFE AND DEATH.

INTRODUCTION.

THAT "Life is short and Art long" is an old proverb and complaint. It appears therefore to follow naturally that I who am earnestly labouring for the perfection of arts should take thought also, by the grace and favour of the Author of Life and Truth, about the means of prolonging the life of man. For though the life of man is only a mass and accumulation of sins and sorrows, and they who aspire to eternity set little value on life; yet even we Christians should not despise the continuance of works of charity. Besides, the beloved disciple survived the rest, and many of the Fathers, especially holy monks and hermits, were long-lived; so that this blessing (so often repeated in the old law) appears to have been less withdrawn after the time of our Saviour than other earthly blessings. But to regard this as the greatest blessing is natural; how to secure it is a difficult inquiry; and the more difficult because it has been corrupted by false opinions and vain reports. For both the common phrases of physicians concerning Radical Moisture and Natural Heat are deceptive, and the extravagant praises of chemical medicines only raise men's hopes to disappoint them.

The present inquiry is not instituted for deaths from

suffocation, putrefaction, and divers diseases, which belong to the history of medicine; but only for that death which proceeds from bodily decay and the atrophy of old age. To inquire however concerning the last step of death and the final extinction of life, which may happen so many ways both external and internal (yet all which meet as it were in a common porch before they come to the point of death), is in my judgment pertinent to this inquiry; but I will reserve it till the end.

Whatever can be repaired gradually without destroying the original whole is, like the vestal fire, potentially eternal. When therefore physicians and philosophers observed that animals were nourished and their bodies repaired and refreshed, but that this was only for a time, as old age soon came on and was speedily followed by dissolution; they looked for death in something that could not be properly repaired, imagining that there was some primitive and radical moisture which was not really repaired, but which even from childhood received a kind of spurious addition and no true repair; and that with time this grew worse and worse, till at last it ended in none at all. But these opinions are very frivolous and ignorant. For in the time of growth and youth all the parts of animals are repaired entirely; nay, for a time they are increased in quantity and bettered in quality, so that the matter whereby they are repaired would be eternal, if the manner of repairing them did not fail. The real truth is this. In declining age repair takes place very unequally, some parts being repaired successfully enough, others with difficulty and for the worse; so that from this time the human body begins to suffer that torture

of Mezentius, whereby the living die in the embraces of the dead, and the parts that are easily repaired, by reason of their connection with the parts hardly reparable, begin to decay. For even after the decline of age the spirit, blood, flesh, and fat are still easily repaired, when the drier or more porous parts, as the membranes, tunicles, nerves, arteries, veins, bones, cartilages, most of the bowels, and nearly all the organic parts are repaired with difficulty and loss. Now these parts when they ought to perform their office of repairing the other reparable parts, being impaired in their powers and activity, are no longer equal to their proper functions; and hence it results that very soon the whole tends to dissolution, and those very parts, which in their own nature are most capable of repair, are yet through the failure of the organs of repair no longer able to be similarly repaired, but decay, and in the end totally fail. The cause of the termination is this; the spirit which like a gentle flame is ever preying on the body, and the external air which likewise sucks and dries bodies, conspiring with the spirit, do in the end destroy the workshop of the body with its machines and organs, and make them incapable of performing the work of repair. Such then are the true ways of natural death, which deserve to be well and carefully considered. For how can a man, who knows not the ways of nature, meet and turn her?

There are therefore two subjects of inquiry; the one, the consumption or depredation of the human body; the other, the repair or refreshment thereof; with a view to the restraining of the one (as far as may be), and the strengthening and comforting the other. The first of these pertains principally to the spirits and ex-

ternal air, which cause the depredation; the second to the whole process of alimentation, which supplies the renovation. With regard to the first part of the inquiry, touching consumption, it has many things in common with bodies inanimate. For whatever the native spirit (which exists in all tangible bodies whether with or without life) and the ambient or external air do to bodies inanimate, the same they try to do to bodies animate, though the presence of the vital spirit in part disturbs and restrains these operations, and in part intensifies and increases them exceedingly. For it is very evident that many inanimate bodies can last a very long time without repair, but animate bodies without aliment and repair at once collapse and die out like fire. The inquiry therefore should be twofold; regarding first the body of man as a thing inanimate and unrepaired by nourishment; and secondly as a thing animate and nourished. And with these prefatory remarks I now pass on to the Topics of Inquiry.

PARTICULAR TOPICS

OR

Articles of Inquiry concerning Life and Death.

1. Inquire into the Nature of Durable and Non-Durable inanimate bodies, and likewise in Vegetables; not in a full and regular inquiry, but briefly, summarily, and as it were only by the way.
2. Inquire more carefully touching the desiccation, arefaction, and consumption of bodies inanimate and vegetable; of the ways and processes whereby they are effected, and withal the methods whereby they are prevented and retarded, and bodies are preserved in their own state. Also inquire touching the inteneration, softening, and renewal of bodies, after they have once commenced to become dry.

Neither however need this inquiry be perfect or exact; as these things should be drawn from the proper title of Nature Durable; and as they are not the principal questions in the present inquiry, but only shed a light on the prolongation and restoration of life in animals; wherein, as has been observed before, the same things generally happen, though in their own manner. From the inquiry concerning inanimate and vegetable bodies pass on to the inquiry of animals, not including man.

3. Inquire into the length and shortness of life in animals, with the proper circumstances which seem to contribute to either of them.
4. Since the duration of bodies is of two kinds, the one in their simple identity, the other by repair; whereof the former takes place only in bodies inanimate, the latter in vegetables and living creatures, and is performed by alimentation; inquire likewise touching alimentation, with its ways and process; yet this not accurately (for it belongs to the titles of Assimilation and Alimentation) but as before, in passing only.

From the inquiry concerning animals and things supported by nourishment pass on to that concerning man. And having now come to the principal subject of inquiry, that inquiry should be more accurate and complete on all points.

5. Inquire into the length and shortness of men's lives, according to the times, countries, climates, and places in which they were born and lived.
6. Inquire into the length and shortness of men's lives, according to their parentage and family (as if it were a thing hereditary); and likewise according to their complexion, constitution, habit of body, stature, manners and time of growth, and the make and structure of their limbs.
7. Inquire into the length and shortness of men's lives according to the times of their nativity; but so as to omit for the present all astrological and horoscopical observations. Admit only the common and manifest observations (if there be

any); as, whether the birth took place in the 7th, 8th, 9th, or 10th month, whether by night or by day, and in what month of the year.

8. Inquire into the length and shortness of men's lives according to their food, diet, manner of living, exercise, and the like. With regard to the air in which they live and dwell, I consider that ought to be inquired under the former article concerning their places of abode.
9. Inquire into the length and shortness of men's lives according to their studies, kinds of life, affections of the mind, and various accidents.
10. Inquire separately into the medicines which are supposed to prolong life.
11. Inquire into the signs and prognostics of a long and short life; not into those which betoken that death is close at hand (for they belong to the history of medicine); but into those which appear and are observed even in health, whether taken from physiognomy or otherwise.

So far the inquiry touching the length and shortness of life is instituted in an unscientific and confused manner; but I have thought it right to add a systematic inquiry, bearing on practice by means of Intentions; which are of three kinds. Their more particular distributions I will set forth when I come to the inquiry itself. The three general intentions are; the prevention of consumption; the perfection of repair, and the renovation of that which is old.

12. Inquire into the things which preserve and exempt the body of man from arefaction and con-

sumption, or at least which check and retard the tendency thereto.

13. Inquire into the things which belong to the general process of alimentation (whereby the body of man is repaired), that it may be good and with as little loss as possible.

14. Inquire into the things which clear away the old matter and supply new; and likewise those which soften and moisten the parts that have become hard and dry.

But since it will be difficult to know the ways to death, unless the seat and house (or rather cave) of death be first examined and discovered; of this too should inquiry be made; not however of every kind of death, but of such only as are caused, not by violence, but by privation and want. For these alone relate to the decay of the body from age.

15. Inquire into the point of death and the porches which on all sides lead to it; provided it be caused by want and not by violence.

Lastly, since it is convenient to know the character and form of old age; which will be done best by making a careful collection of all the differences in the state and functions of the body between youth and old age, that by them you may see what it is that branches out into so many effects; do not omit this inquiry.

16. Inquire carefully into the differences of the state and faculties of the body in youth and old age; and see whether there be anything that remains unimpaired in old age.

NATURE DURABLE.

The History.

With reference to the first Article of Inquiry.

1. Metals last so long that men cannot observe the period of their duration. And even when they do dissolve from age, they dissolve into rust, not through perspiration. Gold however is affected neither way.

2. Quicksilver, though a moist and fluid body and easily made volatile by fire, yet (as far as we know) neither decays nor collects rust by age alone without fire.

3. Stones, especially the harder kinds, and many other fossils are exceedingly durable, even when exposed to the air; and much more so when buried in the earth. But yet they collect a kind of nitre which acts as rust upon them. Precious stones and crystals last even longer than metals, but after a length of time they lose somewhat of their brilliancy.

4. It is observed that stones facing the north decay sooner than those which face the south, as may be seen in obelisks, churches, and other buildings. But iron on the contrary rusts sooner on the south than on the north side, as is shewn on the iron bars or grating of windows. And there is nothing strange in this, seeing that in all putrefactions (and rust is one) moisture accelerates dissolution, as dryness does in simple arefaction.

5. Vegetables when cut down and no longer growing, as the stems or trunks of the harder trees and the timber manufactured from them, last for some ages. But there is a great difference in the parts of the trunk. Some, like the elder, are fistulous, with a soft

pith in the middle, and a harder exterior; but in solid trees like the oak, the interior part (which is called the heart of the tree) is more durable.

6. The leaves, flowers, and even the stalks of plants are of short duration, and unless they putrefy, turn into dust and ashes; but the roots are more durable.

7. The bones of animals last long, as may be seen in charnel-houses where they are stored. Horns also and teeth are very durable, as is seen in ivory, and the teeth of the sea-horse.

8. Skins and hides are very durable, as appears from old parchment books. Paper likewise lasts for many ages, though less durable than parchment.

9. Things which have passed through the fire, like glass or bricks, become very durable. Flesh and fruit also last longer in a cooked than in a raw state. And this is not only because the preparation in the fire prevents putrefaction; but also because, when the watery humour is discharged, the oily humour can support itself longer.

10. Of all liquids, water evaporates the quickest, oil the slowest; as may be seen, not only in the liquids themselves, but also in their compounds. For if paper be moistened with water so as to acquire some transparency, yet it will soon lose it again and turn white, by reason of the evaporation of the water. On the other hand if the paper be dipped in oil, the transparency lasts for a long time, because of the slow evaporation of the oil. And this is the reason why forgers lay oiled paper on an autograph, by means of which they attempt to draw the lines.

11. All gums last a very long time; as do wax and honey.

12. But the equality or inequality of the accidental conditions of bodies contributes as much as the things themselves to their duration and dissolution. Thus timber, stones, and other bodies last longer, if always in the air or always in the water, than if they be sometimes wet and sometimes dry. Stones dug out of the earth and placed in buildings last longer, if they lie in the same direction and point to the same quarter of the heaven as they did in the quarry. This happens likewise in the removal and transplantation of plants.

Major Observations.

1. Let it be assumed, as is most certain, that all tangible bodies contain a spirit or pneumatic body concealed and enveloped in the tangible parts; that by this spirit all dissolution and consumption is commenced; it follows that the antidote against them is the detention of this spirit.

2. This spirit is detained in two ways; either by a close confinement, as in a prison, or by a kind of voluntary detention. This continuance is likewise invited in two ways; namely, if the spirit itself be not very impetuous or pungent, and if moreover it be not much excited by the external air to come forth. Therefore there are two durable substances; namely, the Hard and the Oily; whereof the former binds down the spirit, the latter partly soothes it, and partly is of that nature that it is less acted upon by the air; for air is of the same substance as water, and flame as oil. So much therefore touching nature durable and non-durable in inanimate subjects.

The History.

13. Herbs which are said to be of a colder sort, as lettuce, purslane, wheat, and all kinds of corn, are annual, and perish yearly, both in root and stalk. Yet there are likewise some cold plants that will last three or four years, as the violet, strawberry, burnet, primrose, and sorrel; but borage and bugloss, although they seem so like alive, differ in death; for the borage is an annual, the bugloss longer lived.

14. But most hot plants bear age and years better; as hyssop, thyme, savory, pot-marjoram, balm, wormwood, germander, sage, and the like. Fennel dies in the stalk, but springs again from the root. Basil and sweet marjoram stand age better than cold; for if they are planted in a warm and well sheltered spot they will live more than one year. A knot or figure of hyssop (such as they have in gardens for ornament), clipped twice a year, has been known to last for forty years.

15. Shrubs and bushes live for sixty years; some even twice as long. A vine may continue to bear at sixty. Rosemary also in a favourable situation will live for sixty years; evergreen thorn, and ivy for more than a hundred. The age of the bramble is not observable, since by bowing its head to the ground it strikes new roots, so that it is difficult to distinguish the old from the new.

16. Of the larger trees the longest lived are the oak, the holm-oak, the mountain ash, the elm, the beech, the chesnut, the plane, the fig, the lotus, the wild olive, the olive, the palm, and the mulberry. Of these, some come to the age of eight hundred years, and the most short-lived reach two hundred.

17. Fragrant and resinous trees are in their wood or timber even more durable than those just mentioned; but they are not so long-lived. Such are the cypress, fir, pine, box, and juniper; but the cedar, being assisted by its enormous bulk, almost equals the former in age.

18. The ash, lively and rapid in its growth, lasts for a hundred years or a little more; as sometimes also do the birch, maple, and service tree; but the poplar, lime, willow, and that which they call the sycamore, and walnut, are not so long-lived.

19. The apple, pear, plum, pomegranate, citron, lemon, medlar, cornel, and cherry, sometimes reach their fiftieth or sixtieth year; especially if from time to time they are cleared of the moss that covers some of them.

20. In general, the size of a tree and the hardness of its timber have (if there be nothing adverse in other respects) some connection with their length of life. Trees likewise that bear mast or nuts are generally more long-lived than those that bear fruit or berries. Trees which come into leaf and shed their leaves late last longer than those that are early either in fruit or leaf. Wild trees live longer than orchard trees; and in the same kind trees that have an acid fruit are longer-lived than those with a sweet one.

A Major Observation.

Aristotle has noted well the distinction between plants and animals, as regards alimentation and renovation, namely, that the bodies of animals are confined within their own bounds; and that after they have come to their full growth, they are continued and pre-

served by nourishment, but put forth nothing new except hair and nails, which are regarded as excretions; so that of necessity the juices of animals must soon grow old; whereas in trees, which from time to time put out new branches, new shoots, new leaves, and new fruits, it happens that these parts are always fresh, and untouched by age.[1] But since everything fresh and young draws in nourishment with more strength and vigour than that which has commenced to fade, it happens withal that the trunk, through which the sap passes to the boughs, is itself moistened and refreshed in the passage by a richer and more abundant aliment. And this is further shown (though it was not observed by Aristotle, who likewise has not so clearly expressed that which I have just mentioned,) by this; that in hedges, copses, and pollards, the cutting off of the branches or suckers strengthens the stem or trunk and makes it longer-lived.

DESICCATION; THE PREVENTION OF DESICCATION; AND THE INTENERATION OF THAT WHICH HAS BEEN DRIED.

The History.

With reference to the 2nd Article of Inquiry.

1. Fire and intense heat dry some things, but melt others. "In one and the same fire, clay grows hard and wax melts."[2] Heat dries the earth, stones, wood, cloth, skins, and all bodies that cannot be melted. It melts metals, wax, gums, butter, tallow, and the like.

2. But if the fire be very strong it will in the end

[1] Aristot. De Long. et Brevit. Vitæ, c. 6.

[2] Virgil, Eclog. viii. 80.:

"Limus ut hic durescit, et hæc ut cera liquescit
Uno eodemque igne."

dry up even the things which it has melted. For metals, with the exception of gold, having lost their volatile part in a strong fire, become lighter and more brittle; and oily and fat substances become burnt, scorched, dried up, and crusted.

3. Air, especially open air, manifestly dries, but never melts. Thus roads and the soil when moistened by rain are dried; washed linen exposed to the air is dried; herbs, leaves, and flowers are dried in the shade. But the air acts much quicker either when brightened by the sun's rays (if only it does not produce putrefaction), or when stirred by a gale of wind, and in thorough draughts.

4. Age dries most, but slowest of all things; as is the case in all bodies, which (if putrefaction does not intervene) become dry with age. Not however that age is anything of itself (seeing it is only a measure of time), but the effect is produced by the innate spirit of the body, which sucks out the moisture of the body, and flies out with it; and by the external air, which multiplies itself upon the innate spirits and juices of the body, and preys upon them.

5. Cold has of all things the greatest property of drying; for dryness cannot take place without contraction, and this is the peculiar work of cold. But since men have a very powerful heat in fire, but a very feeble degree of cold (for there is nothing besides that of winter, or perhaps ice and snow, or nitre); the desiccations of cold are weak and easily dissolved. Yet still we see that the surface of the earth is more dried by frost and March winds than by the sun; for the same wind that sucks up the moisture strikes the ground with cold.

6. Smoke from the fire has a drying power, as is shown in bacon and ox-tongues hung up in chimnies. And so fumigations of olibanum, lign aloes, and the like, dry the brain and cure catarrhs.

7. Salt, by a somewhat longer process, dries not only the outside but the inside also; as in salt flesh or fish, which by a long salting are manifestly hardened within.

8. Hot gums applied to the skin dry and wrinkle it; as likewise do some astringent waters.

9. Strong spirit of wine dries as well as fire; so as to blanch the white of an egg put into it, and to toast bread.

10. Powders dry, like sponges, by sucking up the moisture; as is seen in the powder thrown on ink after writing. The polished surface likewise and closeness of the body (which does not permit the vapour of moisture to enter through the pores) accidentally dries it by exposure to the air; as is seen in precious stones, looking-glasses, and sword-blades, which, if you breathe upon them, appear at first covered with a vapour, though it soon disperses like a little cloud. And so much for desiccation.

11. In the eastern parts of Germany, at the present day, they make use of cellars as granaries to keep wheat and other grain. A covering of straw of some depth is laid on the floor below and round the grain, to keep off and absorb the moisture of the cellar; by which means the grain is preserved for twenty or thirty years, not only from rotting, but (what pertains more to the present inquiry) in such a state of freshness as to make excellent bread. The same custom is

said to have prevailed in Cappadocia, Thrace and some parts of Spain.[1]

12. The situation of granaries at the tops of houses, with windows to the east and north, is very convenient. Sometimes two floors are constructed, an upper and a lower one; whereof the upper one is perforated with holes, that the grain (like sand in an hour-glass) may continually fall through the chinks, and after a few days be shovelled up again, so as to keep the grain in constant motion. Now we must observe that a contrivance of this kind not only prevents the corn from rotting, but preserves freshness and checks desiccation; because, as was before remarked, the discharge of the watery humour, which is accelerated by the motion and the wind, preserves the oily part that would otherwise escape with the watery moisture in its proper substance. On some mountains likewise where the air is pure dead bodies will remain many days without much decay.

13. Fruits, as pomegranates, lemons, apples, pears, and the like; and flowers, as roses and lilies, are kept a long time in close earthen vessels. Not however that then they are entirely free from the affection of the external air, which conveys and insinuates its inequalities through the sides of the vessel, as is shown in heat and cold; so that besides carefully stopping the mouths of the vessels, it will be good likewise to bury them in the earth. Or it will answer the same purpose if you sink them in water, provided the water be sheltered, as wells and cisterns in houses; but in this case glass vessels should be substituted for earthen.

14. In general, things kept in the earth, or in cel-

[1] Pliny, xviii. 73.

lars, or in water, preserve their freshness longer than things kept above ground.

15. It is said that in conservatories of snow (whether in the mountains, in natural pits, or in artificial wells), if an apple, chesnut, nut, or anything of the kind happen to fall in, it will be found many months after, when the snow has melted, or even in the snow itself, as fresh and fair as if it had been gathered the day before.

16. Country people keep grapes by covering the bunches with meal, which, though it makes them less pleasant to the taste, yet preserves their juice and freshness. Likewise all the harder fruits last for a long time, not only in meal, but also in sawdust, and even in heaps of grain.

17. It is a common opinion that bodies are preserved fresh in liquors of their own kind, as in their proper *menstrua;* as grapes in wine, olives in oil, and the like.

18. Pomegranates and quinces are preserved by dipping them in sea or salt water, and presently taking them out again, and drying them in the open air in a shady place.

19. Bodies suspended in wine, oil, or lees of oil keep long; much longer in honey and spirit of wine, but the longest of all (according to some) in quicksilver.

20. Fruits covered with wax, pitch, plaster, paste, or other coat or covering, long retain their freshness.

21. It is manifest that flies, spiders, ants, and the like, that have accidentally been inclosed and buried in amber or even the gums of trees, never afterwards decay; though they are soft and tender bodies.

22. Grapes and other fruits are preserved by hang-

ing them up in the air. For in this there is a double advantage; one, that all the bruising or pressure, which happens when they are laid on hard bodies, is avoided; the other, that there is an equal play of the air on all sides of them.

23. It has been remarked that in vegetable bodies neither putrefaction nor desiccation commence alike in every part; but chiefly in that part through which during life aliment was drawn. Hence some recommend to cover up applestalks and fruitstalks with melted wax or pitch.

24. Large wicks of candles or lamps consume the tallow or oil quicker than small ones; cotton-wicks quicker than those of rush, straw, or twig; torches of juniper or fir burn quicker than those of ash; and all flame stirred and fanned by the wind burns faster than in a calm; and therefore slower in a lantern than in the open air. Lamps in tombs are said to last for a very long time.

25. The nature likewise and preparation of the aliment, no less than the nature of the flame, contributes to the length of time they burn. For wax lasts longer than tallow, moist tallow longer than dry, hard wax longer than soft.

26. Trees, if the earth about their roots be stirred every year, last for a shorter time; if every five or ten years, for a longer. Cutting off buds and shoots contributes to their length of life; but manuring, laying chalk and the like about their roots, or much irrigation, though it increases their fruitfulness, shortens their existence. And so much for the prevention of desiccation and consumption.

The inteneration of bodies which have been dried, though the most important part of the matter, presents but few experiments; and I will therefore combine with them some things which happen to animals and even to man.

27. Willow bands used to bind trees become more flexible by being steeped in water. The ends of birch twigs likewise are placed in pots of water to prevent them from withering. Bowls that have cracked from dryness, by being placed in water, close and become whole again.

28. Leathern boots grown hard and stiff with age are softened by being greased with tallow before the fire; and if they are put before a fire alone they get some softness. Bladders and parchment which have become hard, are softened by warm water with an infusion of oil or any fat substance; and more so if besides this they are slightly rubbed.

29. Very old trees, which have long stood untouched, if the earth about their roots be stirred and opened out, manifestly become as it were young again, and put out new and tender leaves.

30. Old draught oxen, entirely worn out, if turned into a fresh pasture, put on new flesh, tender and young, so as even to taste like young beef.

31. A spare and strict diet of guaiacum, biscuit, and the like (such as is used in the cure of venereal diseases, inveterate catarrhs, and the beginning of dropsy,) reduces men to great leanness, by consuming the juices of the body. But these when they begin to be renewed and recruited, appear much more fresh and youthful, so that I judge wasting diseases well cured to have prolonged the lives of many.

Major Observations.

1. It is strange how men, like owls, see sharply in the darkness of their own notions, but in the daylight of experience wink and are blinded. They talk of the elementary quality of dryness, of desiccants, and of the natural periods of bodies, by which they are corrupted and consumed; but in the meantime they observe nothing of any moment, either of the beginnings, or of the intermediate and last acts of desiccation and consumption.

2. The process of desiccation and consumption is performed by three actions, which are derived, as was mentioned before, from the innate spirit of bodies.

3. The first action is the Attenuation of Moisture into Spirit; the second is, the Egress or Escape of the Spirit; the third is, the Contraction of the Grosser Parts of the Body, immediately after the emission of the spirit. And this last is that desiccation and induration whereof I am now principally treating; the two first only consume.

4. With regard to Attenuation, the matter is obvious. The spirit inclosed in all tangible bodies does not forget itself, but whatever it finds therein, that it can digest, work upon, and turn into itself, that it plainly alters and subdues, multiplying itself thereby and generating new spirit. This is confirmed by one proof, which may do for all; that bodies thoroughly dried lose in weight, and become hollow, porous, and sonorous from within. Now it is most certain that the spirit which pre-exists in the body adds nothing to the weight, but rather takes away from it; and therefore it must needs be that this spirit has turned into itself that

moisture and juice of the body, which before weighed; by which means the weight is diminished. This then is the first action; namely, the Attenuation of Moisture and its Conversion into Spirit.

5. The second action, namely the Egress or Escape of the Spirit, is likewise very manifest. This escape, if it takes place all at once, is even apparent to the sense; in vapours to the sight, in odours to the smell; but if it is gradual, as in old age, it is imperceptible to the sense, though it is the same process. Besides, if the texture of the body is so close and tenacious as to prevent the spirit from finding any pores or passages of escape, the spirit in its efforts to get out drives before it the grosser parts of the body and thrusts them beyond the surface; as may be seen in the rusting of metals and the corruption of all fat bodies. This then is the second action; namely, the Egress or Escape of the Spirit.

6. The third action is a little more obscure but equally certain; namely the Contraction of the Grosser Parts after the Emission of the Spirit. In the first place, after the emission of the spirit, bodies seem to be manifestly contracted and to fill less space; as the kernels of nuts when dried do not fill the shell; beams and planks of wood, which at first lay close together, when dried start asunder; bowls and the like crack from dryness; for the parts of the body contract themselves together, and being contracted necessarily leave vacant spaces between them. Secondly, this is shown by the wrinkles of dried bodies; the effort of contraction having so much power as in the meantime to draw the parts together and raise them up; for things that are contracted at the extremities are raised in the cen-

tre. And this may be seen in paper, old parchments, the skin of animals, and the rind of soft cheese, all which with age become wrinkled. Thirdly, this contraction shows itself better in things which are not only wrinkled by heat, but are also folded, crumpled, and as it were rolled up by it; as may be seen by holding paper, parchment, and leaves to the fire. For contraction by age, being a slower process, generally only wrinkles, but contraction by fire being more speedy likewise curls up in folds. But in most bodies, which do not admit of wrinkling or folding, there is a simple contraction, shrinking, induration, and desiccation, as was laid down at first. And if the escape of the spirit and consumption of the moisture is so great as not to leave body enough to unite and contract itself, then the contraction necessarily ceases, the body becomes putrid, and nothing but a little dust hanging together, which with a slight touch is dissipated and passes into air; as may be seen in bodies much decayed, in paper and linen burnt to tinder, and in corpses which have been long embalmed. This then is the third action; namely, the Contraction of the Grosser Parts of the Body after the Emission of the Spirit.

7. It should be observed that fire and heat only dry accidentally, their proper work being to attenuate and dilate the spirit and moisture. But it follows by accident that the other parts contract themselves; whether only to avoid a vacuum, or from some simultaneous motion, whereof I am not now speaking.

8. It is certain that putrefaction as well as arefaction is caused by the innate spirit, though it proceeds in a very different way. For in putrefaction the spirit is not simply discharged, but is in part detained, whence

it produces strange effects. And the grosser parts likewise are not so much locally contracted as collected severally each to its own kind.

LENGTH AND SHORTNESS OF LIFE IN ANIMALS.

The History.

With reference to the 3rd Article of Inquiry.

Transition.

With regard to the length and shortness of life in animals, the information to be had is small, observation careless, and tradition fabulous. Among domestic creatures a degenerate life spoils the constitution; in wild animals severity of weather curtails the natural duration.

Neither is this information much advanced by what may appear to be concomitants; namely, the size of the body, the time of gestation in the womb, the number of young, the time of growth, and the like; for these things are complicated, concurring in some cases and not in others.

1. The age of man (as far as can be gathered from any certain account) exceeds in length that of all other animals, with the exception of a very few. The concomitants in his case are generally regular, his stature and proportion large, his gestation nine months, his offspring commonly single, his age of puberty fourteen, his time of growing up to twenty.

2. The elephant, on undoubted authority, exceeds the ordinary run of human life. The story that its period of gestation in the womb is ten years is fabulous;[1] that it is two years or at least more than one is certain. It is of an immense size, and grows even to

[1] Pliny, viii. 10.

the thirtieth year; the teeth are extremely strong, and it has been observed that the blood is colder than that of any other animal. It sometimes lives two hundred years.

3. Lions have been considered long-lived because many of them are found toothless;[1] but this is a fallacious sign, since it might proceed from their strong breaths.

4. The bear is a great sleeper; a dull and indolent beast, but not remarkable for long life. His period of gestation, which is very short (hardly forty days), is on the contrary a sign of a short life.[2]

5. The fox seems to have many things suitable for a long life; he is very well clothed, feeds on flesh, and lives in holes; but yet he is not noted for longevity. Certainly he belongs to the canine race, which is short-lived.

6. The camel is long-lived; a lean, sinéwy creature, which commonly reaches fifty and sometimes one hundred years.[3]

7. The horse lives only to a moderate age, scarce ever reaching forty, and ordinarily only twenty years. But for this shortness of life he is perhaps indebted to man, since we have now no horses of the sun that range at large in fresh pastures. Yet the horse grows up to its sixth year, and has generative powers in old age. The mare likewise goes longer with young than a woman, and less often produces two at a birth. The ass lives to about the same age as the horse; but the mule longer than either of them.

8. Stags are famed for long life, but upon no certain

[1] Aristot. Hist. An. ix. 44. [2] Id. ib. vi. 30.
[3] Id. ib. vi. 26. and viii. 9.

ground.[1] There is however some story of a stag with a collar round its neck, being found with the collar buried in fat.[2] But the longevity of the stag is the less credible, because it comes to its prime at five years; and not long after, the horns (which they shed and renew annually) grow closer in front, and less branched.

9. The dog is short-lived, its age never reaching beyond twenty, and not often to fourteen. It is an animal of a very hot nature, and lives unequally, being mostly either in violent motion or asleep. It likewise brings forth many in one litter, and goes with them nine weeks.

10. The ox also for its size and strength is short-lived, about sixteen years; the male being somewhat more long-lived than the female. Yet the cow seldom has more than one at a birth, and goes with calf about six months. They are of a dull and fleshy nature, easily fatted, and graminivorous.

11. Sheep seldom live to ten years,[3] though they are a creature of moderate size, and excellently clothed; and what is strange, though they have very little bile in them, their wool is more curled and twisted than the hair of any other animal. The rams do not generate till the third year, and their powers continue till the eighth. The ewes bear young as long as they live. The sheep is a sickly animal, and seldom reaches its full age.

12. The goat lives to about the same age as the sheep, and does not much differ from it in other respects. Though he is a more active creature and his flesh is somewhat firmer, which should make him more

[1] Aristot. Hist. An. vi. 29. [2] Pliny, viii. 50. [3] Pliny, viii. 75.

long-lived; yet he is much more lascivious, which shortens his existence.

13. Swine sometimes live for fifteen or even for twenty years; and though their flesh is moister than that of any other animal, yet this seems to have no effect upon their length of life. Of the wild species nothing certain is known.

14. Cats live between six and ten years; an active animal, and of an acrid spirit, whose seed (according to Ælian) burns the female; whence an opinion has prevailed, "that the cat conceives with pain and brings forth with ease." They eat voraciously, and rather swallow than chew their food.

15. Hares and rabbits scarcely reach to seven years. Both creatures are very prolific, carrying at once the young of several conceptions. They differ in this; that the rabbit lives in holes, the hare above ground; and that the flesh of the hare is of a darker colour.

16. Birds in the size of their bodies are far less than beasts. An eagle or a swan by the side of an ox or a horse, and an ostrich by the side of an elephant, appear small.

17. Birds are excellently clad; since for warmth and close fitting to the body, feathers are better than either wool or hair.

18. Birds, though they hatch many at once, yet do not carry them all together in their bodies, but lay the eggs separately; whence the young are provided with a more plentiful aliment.

19. Birds masticate little, if at all, so that their food is often found whole in their crops. But yet they break

the shells of fruits, and pick out the kernels. They are thought to be of a hot and strong digestion.

20. The flight of birds is a mixed motion formed by the motion of the limbs and that of carriage, which is the most healthy kind of exercise.

21. Aristotle remarked well concerning the generation of birds (but he did wrong to transfer the observation to other animals), that the seed of the male contributes less to generation, but supplies activity rather than matter; whence in many respects prolific and unprolific eggs are not distinguishable.[1]

22. Almost all birds come to their full growth the first year or a little after. It is true that the plumage in some, and the bill in others takes years to come to perfection; but not the size of the body.

23. The eagle is considered long-lived, though its exact age is not ascertained. It is reckoned likewise as a sign of longevity, that he casts his beak, which makes him grow young again; whence comes the proverb, "the old age of the eagle."[2] But perhaps it is not the renewing of the eagle which casts the bill, but the casting of the bill which renews the eagle; for when the beak becomes too hooked, the eagle has great difficulty in feeding.

24. Vultures likewise are said to be long-lived, so as almost to reach a hundred years. Kites also, and all carnivorous birds and birds of prey, are long-lived. The natural age of the hawk cannot be certainly decided, seeing that it leads a servile and degenerate life for the use of man. But tame hawks have sometimes been known to live for thirty years, and wild ones for forty.

[1] Arist. de Gen. Anim. ii. 5.

[2] Erasm. Adagia, i. 9. 57.

25. The raven likewise is reported to live long, sometimes for one hundred years. It feeds on carrion, is not much on the wing, but of sedentary habits, and with a very dark-coloured flesh. The crow, which is like the raven in every respect, except in size and voice, has a somewhat shorter life; yet it is still reckoned among the long livers.

26. The swan is known for certain to be very long-lived, and not unfrequently exceeds one hundred years. It is a bird of most excellent plumage, living on fish, and perpetually carried, and that in running waters.

27. The goose also is one of the long livers; though it feeds on grass and that kind of nourishment. But the wild goose is especially long-lived; so that it passed into a proverb among the Germans, "older than a wild goose."

28. Storks ought to be very long-lived, if the old story is true, that they never went to Thebes, because that city was so often captured.[1] For if this were the case, they either could remember more than one age, or the old ones must have told the story to their young. But all things are full of fables.

29. The story of the phœnix again is so intermixed with fable, that if there was any truth in it, it is completely obscured. But there is nothing very remarkable in that which was looked on as a wonder; namely, how it was always accompanied in its flight by a great number of other birds. For this may be seen anywhere if an owl flies in the daytime, or a parrot escapes from a cage.

30. The parrot has certainly been known to live sixty years in England, in addition to its age when

[1] Cf. Pliny, x. 34.

brought over. It is a bird which will live on all kinds of meat, masticates its food, and from time to time casts its beak; of a bad and mischievous temper, and with a black flesh.

31. The peacock lives twenty years;[1] but it does not get the Argus eyes before the third year; it is slow in walking, and has white flesh.

32. The dung-hill cock is lascivious, pugnacious, and short-lived; a very lively bird, that likewise has white flesh.

33. The Indian or Turkey cock lives longer than the former. It is an irascible bird, with very white flesh.

34. Wood-pigeons are long-lived, sometimes reaching to fifty years; a bird of the air, that builds and sits on high. Doves and turtle-doves are short-lived, not exceeding eight years.[2]

35. Pheasants and partridges sometimes live sixteen years. They are birds that have large broods; with flesh rather darker than that of the pullet tribe.

36. The blackbird is said to be the longest lived of all small birds. It is an impudent bird, but a good singer.

37. The sparrow is observed to be very short-lived,[3] which in the male bird is attributed to its lasciviousness. The linnet, which is not much bigger than a sparrow, has been known to live for twenty years.

38. Of ostriches nothing certain is known, since those kept in England have unfortunately not been found to live long; of the ibis it is only known that it is long-lived, but its age is not recorded.

[1] Cf. Aristot. Hist. An. vi. 9. [2] Id. ib. ix. 7. and Pliny, x. 52.
[3] Arist. Hist. An. ix. 7.

39. The age of fish is more uncertain than that of land animals, because from living under water they are less observed. Most of them have no respiration, and therefore the vital spirit is confined more closely; and though they take in some refrigeration through their gills, yet it is not so continual as by breathing.

40. From living in the water they avoid the desiccation and depredation of the external air. Yet there is no doubt but that the external water entering and abiding in the pores of the body is even more prejudicial to life than the air.

41. They are said to be cold-blooded. Some of them are very voracious, and feed even on their own species. The flesh is softer and less firm than that of land creatures; but they fatten exceedingly, so that an immense quantity of oil is extracted from whales.

42. Dolphins are reported to live about thirty years, an experiment having been made on some of them by cutting off their tails. They continue to grow for ten years.[1]

43. They tell a strange story of fishes, that after some years they diminish much in body, while their heads and tails retain their former size.

44. In Cæsar's fishponds lampreys were sometimes found to live sixty years.[2] Certainly from long habit they grew so tame that Crassus the orator wept over one of them.[3]

45. The pike is found to be the longest lived of all fresh water fish, and sometimes lasts forty years. It is a voracious fish, with a dry and firm flesh.

[1] Arist. Hist. An. vi. 12. [2] Pliny, ix. 78.
[3] Plutarch, De Utilitate ex inim. c. 5. Cf. Pliny, ix. 81.

46. Carp, bream, tench, eels, and the like, are not thought to live more than ten years.

47. Salmon are quick of growth but short of life; as also are trout; but perch are slow of growth and long of life.

48. How long the vast mass of matter in whales and sharks is governed by the spirit is not certainly known; nor in seals, sea-hogs and innumerable other kinds of fish.

49. Crocodiles are said to be very long-lived, and likewise to be remarkable for the time of their growth, so that it is thought that they are the only animals which continue to grow as long as they live.[1] They are oviparous, voracious, savage, and excellently protected against the water. Concerning the age of the other kinds of shell fish, I find nothing certain is known.

Major Observations.

From the neglect of observations, and the complication of causes, it is difficult to discover any rule for the length and shortness of life in animals. Some few things however I will note.

1. More birds than beasts are long-lived (as the eagle, vulture, kite, pelican, raven, crow, swan, goose, ibis, parrot, wood-pigeon, and the like); though they complete their growth in a year, and are of less size. Certainly they are excellently protected against the inclemency of the weather; and as they generally live in the open air, they resemble the inhabitants of pure mountains, who are long-lived. Their movements likewise, which (as has been mentioned elsewhere) are partly by carriage and partly by motion of the limbs,

[1] Pliny, viii.

shake and fatigue them less, and are more healthy. Neither do birds in the first stage of their existence suffer compression or want of aliment in the mother's womb, because the eggs are laid separately. But the principal cause, as I take it, is that birds are made more of the substance of the female than of the male, whence they have a less hot and fiery spirit.

2. It may be laid down that animals which have more of the substance of the female than of the male are longer-lived; as I have just said, birds are. Again, that those which have a longer period of gestation partake more of the substance of the female than of the male, and are therefore more long-lived. Insomuch that even in men (as I have observed in some instances), those who are most like their mother do in my opinion live the longest; as also do the children of old men by young wives, provided the fathers be healthy and not sickly.

3. The beginnings of things are most susceptible both of damage and of help; and therefore the less pressure and the more nourishment that the fœtus receives in the womb the more likely is it to be long-lived. This happens either when the young are brought forth at separate times, as in birds; or when the birth is single, as in animals which only bring forth one at a time.

4. A long period of gestation lengthens life in three ways. First, as has been said, the young partakes more of the substance of the mother; secondly, it comes forth stronger; and thirdly, it is later in undergoing the predatory action of the air. Besides, it denotes that the periods of nature revolve in larger circles. And though sheep and oxen, which remain about

six months in the womb, are short-lived, yet this arises from other causes.

5. Graminivorous and herbivorous animals are short-lived; but those which live on flesh, or even seeds or fruits (as birds do), are long-lived. For stags, which are long-lived, look for half their food (as they say) above their heads; and the goose, besides grass, picks up something in the water to benefit it.

6. The covering of the body I judge to add greatly to longevity, as it prevents and repels the intemperances of the air which so strangely weaken and undermine the body; and with this birds are excellently provided. And though sheep which are well covered are short-lived, this must be attributed to the manifold diseases of the animal and the living upon grass alone.

7. The principal seat of the spirits is doubtless in the head; and though this is commonly referred only to the animal spirits, yet it applies to all. And there is no question that the spirits most absorb and consume the body, so that a larger quantity of them or a greater inflammation and acrimony greatly shortens life. It appears to me therefore that the great cause of longevity in birds is that they have such small heads for the size of their bodies; whence men likewise who have very large heads are, I think, shorter lived.

8. Carriage, as has been before observed, I judge more than any other motion to contribute to longevity. Water-birds, as the swan, are carried on the water; and all birds are carried as they fly, using however from time to time a strong exertion of the limbs. So also are fishes in swimming, but their length of life is uncertain.

9. Animals which come later to perfection (I am

not speaking of growth in stature only, but of the other steps to maturity; as man puts out first his teeth, then his signs of puberty, then his beard, &c.), are longer-lived; for it indicates that the periods return in wider circles.

10. The gentler kinds of animals, as the sheep and dove, are not long-lived; for bile acts as a whetstone or spur to many functions of the body.

11. Animals whose flesh is somewhat dark-coloured live longer than those with a white flesh; for it denotes that the juice of the body is firmer, and less easily dissipated.

12. In every corruptible body quantity itself contributes much to the preservation of the whole. For a large fire is not so soon quenched; a small quantity of water evaporates sooner; a twig withers sooner than the trunk. Generally therefore (I speak of kinds, not of individuals) animals of a larger bulk are more long-lived than those of a smaller; unless there is some other powerful cause to prevent it.

ALIMENTATION; AND THE WAY OF NOURISHING.

The History.

With reference to the 4th Article.

1. Nourishment should be of an inferior nature and a simpler substance than the body nourished. Plants are nourished by earth and water, animals by plants, men by animals. There are animals likewise which feed on flesh, and man himself feeds partly on plants; but man and carnivorous animals could hardly be nourished by plants alone. From time and habit they might perhaps be nourished by fruits and seeds that had passed the fire, but not by

the leaves of plants or herbs; as has been proved by the order of the Feüillans.

2. Too near a relationship or similarity of substance between the nourishment and the thing nourished does not turn out well. Graminivorous animals do not touch flesh; even of carnivorous animals few eat the flesh of their own species; nor do men that are cannibals feed ordinarily upon man's flesh, but take to it either for revenge on their enemies, or from some unnatural custom. A field is not well sown with the grain which grew in it, nor is the sucker or shoot grafted on its own stock.

3. The better the aliment is prepared, and the nearer it assimilates to the substance of the thing nourished, the more fruitful do plants become, and the more do animals fatten. For no shoot or sucker planted in the ground is so well nourished as if it were grafted on a stock well suited to its nature, where it found its nourishment digested and prepared. Neither (it is said) will the seed of an onion or the like, put into the earth, produce so large a plant as it would if it were first grafted into the root of another onion, and then put into the earth. Again, it has been recently discovered that shoots of wild trees, as the elm, oak, ash, and the like, bear far larger leaves when grafted on other stocks than they do naturally. Men likewise are better nourished by cooked than by raw food.

4. Animals are nourished through the mouth, plants through the roots, the fœtus of animals in the womb through the navel cord, and birds for a short time by the yolk of their eggs, some of which is even found in their crops after they are hatched.

5. All aliment moves principally from the centre

towards the circumference, or from the inside towards the outside. But it should be observed that trees and plants are rather nourished through the bark and outside, than through the pith and inside; for if even a narrow strip of bark be peeled off all round the trunk the tree soon dies. And blood in the veins of animals nourishes the flesh beneath it as well as that above it.

6. In all alimentation there are two actions, extrusion and attraction; whereof the former proceeds from an interior, the latter from an exterior function.

7. Vegetables assimilate their aliment simply and without excretion; for gums and tears are rather exuberances than excretions, and knobs are diseases. But the substance of animals having a better perception of its like, is the more fastidious, and rejects the useless and assimilates the useful matter.

8. It is curious that all the aliment, which sometimes produces such large fruit, should have to pass through such a slender neck as the fruitstalk; for fruit never grows to the stem without a stalk.

9. It should be observed that the seed of animals is only fruitful when fresh, but that the seeds of plants retain the power of nourishment for a long time. But yet shoots will not grow unless they are put in fresh; and roots will soon lose their vegetative power if they are not covered with soil.

10. In animals the degrees of nourishment vary according to the age. For the fœtus in the womb the juices of the mother are enough: after birth, milk; afterwards, meat and drink; and in old age heavier and more savoury meats are generally the most pleasing.

Injunction. The point of most importance to the pres-

ent inquiry is to examine clearly and carefully whether nourishment may not be supplied from without, at all events otherwise than through the mouth. We know that milk-baths are used in consumptions and wasting diseases, and that there are some physicians who consider that some alimentation may be supplied by clysters. By all means pay attention to this: for if nourishment can be made to pass either from without, or otherwise than through the stomach, then the weakness of digestion which attacks old men may by these means be compensated and the power of digestion as it were restored.

LENGTH AND SHORTNESS OF LIFE IN MAN.

The History.

With reference to the 5th, 6th, 7th, 8th, 9th, and 11th Articles.

1. Before the flood men lived according to Scripture many hundred years, yet none of the patriarchs reached to a thousand. Neither can this longevity be imputed to grace or the holy line. For of the patriarchs before the flood there are counted eleven generations, but of the sons of Adam by Cain only eight; which would make Cain's descendants the more long-lived. Immediately after the flood this longevity was reduced by a half; at least in such as were born after the flood (for Noah who was born before it arrived at the age of his ancestors, and Shem lived 600 years).[1] And when three generations had passed the life of man was reduced to about a fourth of his original age; that is, to about 200 years.

2. Abraham lived 175 years;[2] a man of noble spirit,

[1] Gen. xi. 10, 11.

[2] Gen. xxv. 7.

and prosperous in all his ways. Isaac attained to 180 years;[1] a chaste man, and of a quiet life. Jacob after many sorrows and a numerous family reached his 147th year;[2] a man patient, gentle, and cunning. Ishmael, a warlike man, lived 137 years.[3] Sarah (the only woman whose age is recorded) died in the 127th year of her age;[4] a woman of a fair countenance, and of a noble spirit, an excellent wife and mother, and no less distinguished for her frankness than for her duty to her husband. Joseph likewise, a wise and politic man, who passed his youth in affliction but his after age in great prosperity, lived 110 years.[5] Levi his elder brother completed his 137th year;[6] a man of a revengeful nature, and impatient of insult. The son of Levi, and likewise his grandson, the father of Moses and Aaron, reached nearly the same age.[7]

3. Moses lived 120 years;[8] a man of courage, and yet of the greatest meekness, and hesitating in his speech. But he himself in his Psalm declared the life of man to be only threescore years and ten, and if a man be strong, fourscore years;[9] which certainly has been the general standard of life up to the present day. Aaron, who was three years older, died the same year as his brother;[10] a man readier of tongue, easier and less firm in character. Phineas, Aaron's grandson, is computed to have lived (perhaps by extraordinary grace) 300 years, if at least the war of the Israelites against the tribe of Benjamin[11] (wherein Phineas was consulted) took place in the same order of time as is recorded in the history; he was a man exceedingly

[1] Gen. xxxv. 28. [2] Gen. xlvii. 28. [3] Gen. xxv. 17.
[4] Gen. xxiii. 1. [5] Gen. l. 26. [6] Exod. vi. 16.
[7] Exod. vi. 18. and 20. [8] Deut. xxxiv. 7. [9] Psalm xc. 10.
[10] Numb. xxxiii. 29. [11] Judges, xx. 28.

zealous. Joshua, a warrior, a renowned and ever successful general, lived 110 years.[1] Caleb his contemporary appears to have lived to about the same age. Ehud the judge seems to have been a centenarian at least; for after the conquest of the Moabites the Holy Land had rest for eighty years under his government;[2] he was a bold and active man, who had in a manner devoted himself for the people.

4. Job after the restoration of his prosperity lived 140 years;[3] and before his afflictions he was old enough to have grown-up sons; he was a man politic, eloquent, charitable, and a model of patience. Eli the priest lived ninety-eight years;[4] a corpulent man, of a quiet temper, and indulgent to his children. Elisha the prophet seems to have been above 100 at his death, since we find that he lived sixty years after the assumption of Elijah, and at that time the boys mocked him as a bald-head.[5] He was a vehement and severe man, a strict liver, and a despiser of riches. Isaiah the prophet seems to have been a centenarian, for he is found to have exercised the gift of prophecy for seventy years; but the time he commenced to prophesy and the time of his death are both uncertain. He was a man of wonderful eloquence, and the evangelical prophet, being full of God's promises of the New Testament, as a skin full of sweet wine.

5. Tobias the Elder lived 158 years: the Younger, 127 years;[6] both men compassionate and charitable. At the time of the captivity likewise, many of the Jews who returned from Babylon appear to have been of a great age; since (though there was an in-

[1] Josh. xxiv. 29. [2] Judges, iii. 30. [3] Job, xlii. 16.
[4] 1 Sam. iv. 15. [5] 2 Kings, ii. 23. [6] Tobit, xiv. 11. 14.

terval of seventy years) they are said to have remembered both temples, and to have wept for the disparity between them.[1] After the lapse of several ages, in the time of our Saviour, Simeon is found to have reached 90 years; a religious man, full of hope and expectation. At the same time likewise Anna the prophetess is proved to have lived more than 100 years;[2] for she had lived with her husband for seven years, and been a widow for eighty-four, and to these must be added the years of her virginity, and those which followed her prophecy of our Saviour. She was a holy woman, passing her life in prayer and fasting.

6. The instances of longevity mentioned in heathen authors are not to be depended on; both by reason of the fables, to which relations of this kind are very prone, and the fallacies in the calculations of years. In the accounts extant concerning the Egyptians there is certainly nothing remarkable as to longevity. For the longest reign of any of their kings did not exceed fifty or fifty-five years; which is nothing, seeing that modern reigns are sometimes as long. The kings of Arcadia are fabulously reported to have been very long-lived.[3] Certainly it is a mountainous and pastoral country, and the mode of life pure and uncorrupted; but yet, seeing that Pan was its tutelar deity, everything belonging to it appears to have been Panic, superstitious, and fabulous.

7. Numa the Roman king was an octogenarian;[4] a man peaceful, contemplative, and devoted to religion. M. Valerius Corvinus was a centenarian; since forty-

[1] Ezra, iii. 12.
[2] St. Luke, iii. 36, 37.
[3] Pliny, vii. 49.
[4] Lucian, Macrobii, 8.

six years elapsed between his first and sixth consulship.[1] He was a very brave and warlike man, affable, popular, and always fortunate.

8. Solon the Athenian lawgiver, and one of the seven wise men, lived for more than 80 years.[2] He was a man of noble spirit, but popular, and devoted to his country; at the same time learned, and yet not averse to pleasure and the softer kind of life. Epimenides of Crete is said to have lived 157 years; but the case has something of prodigy in it, since for fifty-seven of them he is said to have lain concealed in a cave.[3] Half a generation after this, Xenophanes of Colophon lived 102 years, or even longer; for he left his native country at twenty-five, travelled full seventy-seven years, and then returned;[4] but how long he lived after his return does not appear. He was a man who wandered no less in his mind than in his body; so that in consequence of his opinions his name was changed from Xenophanes to Xenomanes; he was doubtless a man of vast conceptions, breathing nothing but infinity.

9. Anacreon the poet lived beyond 80;[5] a man amorous, voluptuous, and a wine-bibber. Pindar the Theban completed his 80th year;[6] a sublime poet, with a certain novelty and originality of mind, and a great worshipper of the gods. Sophocles the Athenian lived to the same age;[7] a poet of a lofty style, entirely devoted to writing, and neglectful of his family.

10. Artaxerxes the Persian king lived 94 years;[8] a man of a dull intellect, averse to important business,

[1] Pliny, vii. 49.
[2] Diog. Laert. i. 62.
[3] Pliny, vii. 49.
[4] Diog. Laert. ix. 19.
[5] Lucian, Macrob. 26.
[6] Fabricius, Biblioth. Græca, ii. 14.
[7] Lucian, Macrob. 34.
[8] Lucian Macrob. 15.

loving glory much, but ease more. Agesilaus, king of Sparta, at the same period attained to 84 years;[1] a moderate man, and a philosopher among kings; but nevertheless ambitious, warlike, and active both in war and business.

11. Gorgias of Leontini lived 108 years;[2] a rhetorician, who made great display of his wisdom, and visited many countries, instructing youth for pay; and a little before his death said, "that he had no cause to complain of old age."[3] Protagoras of Abdera lived 90 years.[4] He likewise was a rhetorician, but professed not so much to deal with the whole circle of knowledge as to teach civil business and the art of government; yet he, like Gorgias, was a great traveller. Isocrates of Athens completed his 98th year;[5] being likewise a rhetorician, but an extremely modest man, who avoided the forum, and only opened his school at home. Democritus of Abdera lived to 109.[6] He was a great philosopher, and a true student of nature, if ever Greek was; a great traveller in countries, but a greater still in the works of nature; a diligent experimenter; and (as Aristotle objects) a follower of similitudes rather than an observer of the laws of argument. Diogenes of Sinope lived 90 years;[7] a man free towards others, but despotic over himself, delighting in poor diet, and patience. Zeno of Citium lived 98 years;[8] a high-minded man, a scorner of opinions, of great acuteness, yet not of a troublesome kind, but such as rather engaged and took men's minds than constrained them; wherein Seneca afterwards resem-

[1] Plut. in Agesil. p. 618.
[2] Pliny, vii. 49.
[3] Cic. de Senect. 5.
[4] Diog. ix. 55.
[5] Lucian, Macrob. 23.
[6] Diog. Laert. ix. 43.
[7] Diog. Laert. vi. 76.
[8] Diog. Laert. vii. 28.

bled him. Plato the Athenian fulfilled his 80th year;[1] a man of a great spirit, but loving quiet, in contemplation sublime and imaginative, in manners polite and elegant, but yet rather composed than merry, and of a majestic carriage. Theophrastus of Eresium lived 85 years;[2] a man pleasant for his eloquence and his great variety of information; who only picked out the sweets of philosophy and did not meddle with the unpleasant or the bitter. Carneades of Cyrene, many years afterwards, likewise reached his 85th year;[3] a man of easy eloquence, who delighted both himself and others with the pleasant and agreeable variety of his knowledge. Orbilius in Cicero's time, who was neither a philosopher nor a rhetorician, but a grammarian, lived nearly 100 years;[4] first a soldier, then a schoolmaster; a man naturally harsh and rough, both with his tongue and pen, and very severe to his pupils.

12. Q. Fabius Maximus was augur for sixty-three years,[5] and therefore he must have been above eighty when he died; though it is true that in the augurship noble birth was usually more regarded than age. He was a wise and cautious man, moderate in all his ways of life, and uniting courtesy with severity. Masinissa the Numidian king exceeded 90 years, and had a son after he was eighty-five.[6] He was a bold man, confident of fortune, who experienced many vicissitudes in his youth, but was uniformly fortunate in his old age. M. Porcius Cato lived for more than 90 years,[7] a man of iron both body and mind, severe in speech, a

[1] Lucian Macrob. 21.; Diog. Laert. iii. 2.
[2] Diog. Laert. v. 40.
[3] Diog. Laert. iv. 65.; Luc. Macrob. 20.
[4] Suetonius, De Illustr. Grammat. c. 9.
[5] Pliny, vii. 49.
[6] Valerius Maximus, De Gratis.
[7] Cf. Cic. De Senect. 10. and De Amic. 3.

lover of party strife, fond of agriculture, and physician both to himself and his family.

13. Terentia, the wife of Cicero, lived for 103 years;[1] a woman oppressed by many sorrows, first by the banishment of her husband, then by the quarrel between them, and lastly by his final misfortune; she was likewise often troubled with the gout. Luceia must have lived a good deal beyond 100 years;[2] since she is said to have acted for a full century on the stage, playing perhaps at first the part of a girl, and lastly that of a decrepit old woman. It is unknown in what year of her age Galeria Copiola, who was both an actress and a dancer, was first brought on the stage; but ninety-nine years after her first appearance she was brought back to the stage on the dedication of the theatre by Pompey the Great, not now as an actress, but as a wonder. And this is not all; for she was exhibited again at the votive games in honour of Augustus.[3]

14. There was also another actress, a little inferior in age but of a higher rank, who lived nearly 90 years; namely, Livia Julia Augusta, wife of Augustus, mother of Tiberius.[4] For if the life of Augustus was a play (as he himself signified, when on his death-bed he told his friends to give him a "plaudite" as soon as he expired), so certainly was Livia an excellent actress, who could so well unite obedience to her husband with power and authority over her son. She was a courteous woman, yet matronly, busy, and tenacious of power. Junia, the wife of C. Cassius, and sister of M. Brutus, lived also to 90; since she lived sixty-four

[1] Pliny, vii. 49. [2] Pliny, vii. 49. [3] Pliny, vii. 49.
[4] Cf. Dio Cassius, p. 621., and Pliny, xiv. 8.

years after the battle of Philippi.[1] She was a woman of noble spirit and great wealth, unhappy by reason of the fate of her husband and her nearest relations, and her long widowhood, but yet much respected.

15. The 76th year of our Lord, in the reign of the Emperor Vespasian, is memorable as furnishing a kind of calendar of longevity.[2] For in this year a census (which gives the best and most trustworthy information as to the ages of men) was taken, and in that portion of Italy which lies between the Apennines and the Po there were found 124 men who had reached or passed their hundredth year; namely, fifty-four men 100 years old, fifty-seven men 110, two men 125, four men 130, four men 135 or 137, and three men 140. Besides these, Parma in particular returned five men, of whom three were 120, and two 130 years old; Brixillum one man of 125; Placentia one of 131; and Faventia, one woman of 132. A town (then called Velleiacum), situated on the hills surrounding Placentia, returned ten, of whom six had completed their 110th, and four their 120th year; and Ariminum, one man aged 150 years, named M. Aponius.

Admonition. To avoid prolixity, I have thought fit both in the instances already recounted and in those which I am going to recount, to bring forward no age less than 80; and I have appended to each a character or biographical notice, true and very short, but such as in my judgment has some bearing upon longevity (which is in no slight degree influenced by fortune and habits); either because such persons are commonly long-lived, or on the contrary

[1] Tacitus, Ann. iii. 76.

[2] Cf. Pliny, vii. 5.

because such persons, though not apt to live long, yet sometimes may.

16. Of the Roman, Greek, French, and German emperors, up to our time, containing a list of about 200 princes, only four have been found to reach the age of 80. To these we may add the two first emperors, Augustus and Tiberius; the latter being 78, the former 76;[1] and both of whom might perhaps have reached 80, if Livia and Caligula had so willed it. Augustus (as has been mentioned) lived 76 years; a man of a moderate disposition, vehement in accomplishing his designs, but in other respects quiet and serene, temperate in his diet, but not so in his amours, and fortunate in everything. In his thirtieth year he had so severe and dangerous an illness that his life was despaired of; when the physician Antonius Musa, after all the rest had applied hot remedies as suited for the disease, cured him by a contrary system of cold medicines;[2] and this perhaps contributed to his length of life. Tiberius lived to be two years older; a man (as Augustus said of him[3]) of slow jaws, that is, of slow but strong speech; bloodthirsty, intemperate, and one who made lust part of his diet; and yet he took good care of his health, for he used to say that a man must be a fool who called in or consulted a physician after he was thirty. The elder Gordian lived 80 years, and yet died a violent death, before he had scarce tasted the sweets of empire. He was a man noble and magnificent, learned and a poet, and up to the very time of his death uniformly fortunate. The Emperor Va-

[1] Suetonius in August. 100., and in Tiber. 73.
[2] Sueton. in August. 81.
[3] Sueton. in Tiber. 21.

lerian lived 76 years before he was taken prisoner by the Persian king Sapor; he lived after his captivity seven years in the midst of insult, and in the end died a violent death. He was a man of indifferent capacity, and not active; but of a somewhat higher reputation than he proved himself equal to in action. Anastasius, surnamed Dicorus, lived 88 years; a man of a sedate temper, but low-spirited, superstitious and timid. Anicius Justinianus lived 83 years; an ambitious man, personally indolent, but successful and famous through the valour of his generals; uxorious, and not his own master, but under the guidance of others. Helena of Britain, the mother of Constantine the Great, was an octogenarian. She was a woman who never interfered in public affairs, either during the reign of her husband or of her son, but entirely devoted herself to religion; she was high-minded, and always prosperous. The Empress Theodora (who was the sister of Zoe, the wife of Monomachus, after whose death she reigned alone) lived above 80 years. She was a busy woman and fond of empire, excessively fortunate, and rendered credulous by her prosperity.

17. From secular princes, I will now turn to the principal persons in the Church. St. John, the apostle and beloved disciple of our Saviour, lived 93 years; rightly denoted by the emblem of the eagle, breathing nothing but divine love, and distinguished as a seraph among the apostles by reason of the fervour of his charity. St. Luke the Evangelist lived to 84;[1] an eloquent man, a traveller, the inseparable companion of St. Paul, and a physician. Simeon the son of Cleophas, called the brother of our Lord, and Bishop of

[1] Baronius, i. 586.

Jerusalem, lived 120 years,[1] and was then cut off by martyrdom; a high-spirited man, stedfast in the faith, and full of good works. Polycarp, the disciple of the Apostles, and Bishop of Smyrna, seems to have lived for more than 100 years before he suffered martyrdom; a man of high soul, heroic patience, and incessant in his labours.[2] Dionysius the Areopagite, the contemporary of the Apostle Paul, seems to have lived 90 years. From the high flight of his divinity he was surnamed "the Bird of Heaven;" and he was no less distinguished for his works than for his meditations. Priscilla and Aquila, first the hosts of the Apostle Paul, and then his fellow-labourers, lived in a happy and famous wedlock for at least 100 years, since they were alive under the papacy of Sistus I. They were a noble pair, and given to all charity; who, besides other great consolations (which were doubtless vouchsafed to the early founders of the Church), had this great additional blessing of conjugal union. St. Paul the hermit reached 113 years. He lived in a cave, on such simple and hard diet as would appear scarce sufficient to support life; passing all his time in meditations and soliloquies, and yet not illiterate, or an idiot, but a learned man. St. Antony, the first founder, or (according to some) the restorer of the monkish orders, reached the age of 105;[3] a devout man, and contemplative, but yet a good man of business; his manner of life was rough and austere, but yet he lived in a kind of glorious solitude, and not without authority. For he both had his monks under him, and moreover many Christians and philosophers came to visit him, as

[1] Eusebius, Hist. iii. 29. [2] Eusebius, Hist. iv. 15.
[3] St. Athanas. Vita S. Anton. c. 89.

a living image, not without some feelings of adoration. St. Athanasius was above 80 when he died; a man of invincible firmness, always commanding fame, and never giving way to fortune; free towards those above him, courteous and acceptable to those below; practised in contentions, and both courageous and prudent therein. St. Jerome, by the authority of most writers, exceeded 90 years; a powerful writer and a manly speaker; learned both in languages and sciences, and a great traveller. In his old age he was more austere in his living; but though his life was private his spirit was high, and his light shone far out of his obscurity.

18. The Popes of Rome, up to the present time, are in number 241. Of these only five have reached or exceeded 80; but many of the early popes had their natural life cut short by martyrdom. John XXIII., Pope of Rome, completed his 90th year; a man of a restless disposition, who being fond of change altered many things, some to the better, not a few merely to something else; but a great accumulator of wealth and treasure. Gregory XII., who was created Pope during a schism, a kind of an interrex, died in his 90th year; but his papacy was so short, that I find nothing to observe concerning him. Paul III. lived to 81; a man of sedate temper and deep wisdom, a learned man and an astrologer, and very careful of his health; but, like the old priest Eli, indulgent to his relations. Paul IV. lived 83 years; a man naturally harsh and severe, of a haughty and imperious spirit, of a passionate temper, but eloquent and ready of tongue. Gregory XIII. likewise reached the same age; a truly good man, sound in mind and body, politic, temperate, and full of good and charitable works.

19. The cases which follow are promiscuous in their order, more doubtful in authority, and more scanty in observation. Arganthonius, king of Cadiz in Spain, lived 130 or (according to some) 140 years, for eighty of which he was on the throne.[1] Of his manners, habits of life, and the time in which he lived, nothing is recorded. Cinyras, king of Cyprus, is said to have lived 150 or 160 years in that island, then reputed happy and voluptuous.[2] Two Latin kings of Italy, father and son, are said to have lived 800 and 600 years respectively; but this is only recorded by certain philologists, who (though otherwise credulous enough) have themselves doubted the truth of this story, nay, rather condemned it.[3] Some kings of Arcadia are mentioned as having lived 300 years.[4] The country certainly is well adapted for long life, but perhaps the matter is exaggerated by fables. There is a story of one Dando in Illyria who lived 500 years, without any of the inconveniences of old age.[5] It is said that among the Epii, which is a part of Ætolia, all the people are very long-lived, many of them having been known to live 200 years. One of them especially, by name Litorius, a man of gigantic stature, had reached to 300.[6] On the top of Mount Tmolus (anciently called Tempsis) many of the inhabitants are said to have lived 150 years.[7] The Essenes among the Jews are related to have generally lived above 100 years;[8] but that sect lived on a very simple diet, after the Pythagorean order. Apollonius of Tyana exceeded

[1] Cic. De Senec. 19.; Herod. i. 163.; Val. Max. viii. 13.; Pliny, vii. 49.
[2] Pliny, vii. 49.
[3] Pliny, vii. 49.
[4] Pliny, vii. 49.
[5] Pliny, vii. 49.
[6] Valerius Maximus, xiii. 6.; Pliny, vii. 49.
[7] Pliny, vii. 49.
[8] Joseph. De Bello Judaic. ii.

100 years;[1] a man beautiful for his age, and truly wonderful; regarded as a god by the heathens, as a sorcerer by the Christians; a Pythagorean in his diet, a great traveller, of immense renown, and worshipped almost as a god; nevertheless towards the close of his life he had to undergo accusations and disgrace, though he contrived to escape in safety. But lest his longevity should be attributed to his Pythagorean diet alone, and to show that he derived some of it from his family, it may be mentioned that his father likewise lived 130 years. It is certain that Q. Metellus lived upwards of 100 years;[2] and after a successful administration of several consulships, being in his old age made Pontifex Maximus, he held that sacred office for twenty-two years; yet his voice never faultered in repeating the vows, neither did his hands tremble in performing the sacrifices. Appius Cæcus was certainly very old, but his age is not recorded.[3] He was blind for the greater part of his life; but no way softened by this misfortune, he governed a numerous family, a great retinue of clients, nay, the state itself, with a vigorous hand. Nay, in his last days, when carried on a litter into the senate, he spoke most earnestly against making peace with Pyrrhus. The beginning of his speech is very memorable, as showing the invincible strength and vigour of his mind: "For these many years," said he, "conscript fathers, have I borne my blindness with extreme impatience; but now I could even wish myself deaf also, when I hear you talking of such dishonourable counsels."[4] M. Perpenna lived 98 years; having survived all those whose vote

[1] Philostr. in Vit. Appoll. c. 13.
[2] Val. Max. viii. 13.
[3] Val. Max. viii. 13.
[4] Plut. i. 394.

he as consul had asked in the senate (that is, all the senators during his year of office); and also, with the exception of seven, all those whom a little after as censor he had elected into the senate.[1] Hiero, king of Sicily in the time of the second Punic war, was almost a centenarian;[2] a man moderate both in his government and manners, a worshipper of the gods, a strict observer of friendship, liberal, and uniformly fortunate. Statilia, of a noble family, in the time of Claudius, lived 99 years;[3] Clodia, the daughter of Ofilius, 115.[4] Xenophilus, an old Pythagorean philosopher, lived 106 years;[5] a hale and vigorous old man, with a great reputation among the people for learning. The Corcyreans were anciently reputed long-lived, but now their age is of the ordinary length. Hippocrates of Cos, the famous physician, lived 104 years, and by the length of his life approved and credited his own art. He was a man of wisdom as well as learning, much given to experiments and observation, not striving after words or methods, but picking out the very nerves of science and so setting them forth. Demonax, a philosopher (both by practice and profession) in the time of Adrian, lived almost to 100;[6] a man of high mind and master of his mind, and that truly without affectation; a despiser of the world, but courteous and polite. When his friends asked him about his burial, he replied, "Take no care about my burial, for stench will bury a corpse." "Do you wish, then," said they, "to be thrown out to the dogs and birds?" "If," said he, "in my lifetime I did my best to benefit man, what harm is there if,

[1] Pliny, vii. 49. [2] Val. Max. viii. 13. [3] Pliny, vii. 49.
[4] Id. ib. [5] Lucian, Macrob. c. 18. [6] Lucian, Demonax, 66.

when I am dead, I likewise do something for the animals?" A people of India called Pandoræ are very long-lived, lasting even for 200 years.[1] They say also (which is more strange) that their hair, which is nearly white in boyhood, turns black in old age, before it grows hoary; though indeed it is common everywhere for light hair in the boy to turn darker in the man. The Seres likewise, another Indian people, with their palm-wine, are reputed to live as long as 130 years.[2] Euphranor the grammarian continued to teach in his school till he was above 100.[3] The elder Ovid, the father of the poet, lived 90 years; he was of a different character from his son, as he despised the Muses and dissuaded his son from poetry.[4] Asinius Pollio, the friend of Augustus, exceeded 100 years.[5] He was a man extremely luxurious, eloquent, and devoted to literature; but yet violent, proud, cruel, and selfish. It is a common idea that Seneca was very old, and no less than 114. But this cannot be true; for far from being a decrepit old man when he was appointed tutor to Nero, he was on the contrary exceedingly active in the government. Besides, a little before, in the middle of the reign of Claudius, he was banished for adultery with some noble ladies, a thing not compatible with such an age. Johannes de Temporibus among all the men of later times is by tradition and common report reputed long-lived, even to a miracle or rather a fable, his age being said to be above 300. He was by birth a Frenchman, and served under Charlemagne. Gartius of Aretium, great grandfather to Petrarch, lived 104 years. He always enjoyed good health, and

[1] Pliny, vii. 2. [2] Cf. Pliny, vii. 2. [3] Suidas in v. Apion.
[4] Ovid, Tristia, iv. 10. 77. [5] Cf. Pliny, xxii. 53.

at the end felt a decay of strength rather than any malady; which is the true dissolution by old age. Many Venetians of high rank were long-lived; as the Doge Franciscus Donatus, Thomas Contarenus and Franciscus Molinus procurators of St. Mark, and others. But the most memorable instance is that of the Venetian Cornaro, who being of sickly body in his youth, began for the sake of his health to measure his meat and drink by weight. This custom led by degrees to a fixed diet, and the diet to a very long life, of even more than 100 years,[1] with unimpaired faculties and constant health. Guillaume Postel, a Frenchman, in our time, lived nearly 120 years; the top of his moustache being still black, and not at all grey. He was a man of disordered brain and unsound mind, a great traveller and mathematician, and somewhat tainted with heresy.

20. In England I imagine there is scarce any village of any size in which an octogenarian man or woman may not be found. A few years ago, at a May-game in Herefordshire, a morrice dance was performed by eight men, whose united ages made up 800 years; some of them exceeding 100, by as much as others fell short.

21. In Bethlehem hospital in the suburbs of London, instituted for the support and custody of lunatics, there are found from time to time madmen who live to a great age.

22. The ages of nymphs and demons of the air, who are represented as mortal, yet as very long-lived (a thing that has been admitted by the superstition and credulity of the ancients, and even by some in modern

[1] Flourens, De la Longevité, p. 33.

times), I hold to be fables and dreams; especially as they agree neither with philosophy nor religion.

And so much for the history of longevity in man considered in individual cases or next to individual. I will now proceed to observations by certain heads.

23. The lapse of ages and the succession of generations do not appear to have at all diminished the length of life. For from the time of Moses to the present day the course of man's life has stood at about eighty years, not gradually and insensibly declining, as might have been expected. There are periods indeed in every country when men are longer or shorter lived. Longer generally, when they are less civilised, live on simpler diet, and are more given to bodily exercise; shorter, when they are more civilised and given more to ease and luxury; but these things come and go in their turns; the succession of generations has nothing to do with them. And no doubt the same holds good with the other animals; since neither oxen nor horses, nor sheep and the like, have become more short-lived in these latter times. Therefore the great diminution of age was caused by the flood; and may perhaps by the like great accidents (as they call them), such as particular inundations, long droughts, earthquakes and the like, be caused again. And this seems to hold good likewise in the size or stature of the body. For neither has this deteriorated through the succession of generations; though Virgil (following the common opinion) prophesied that posterity would be smaller than the men of that age; and therefore in speaking of the ploughing of the Æmathian and Æmonian fields, he says, "the husbandman will wonder at the huge bones that shall be dug

up."[1] It is certain indeed, from remains found in old tombs and caverns in Sicily and elsewhere, that men of gigantic stature formerly existed; but now for 3000 years, a time whereof our information is certain, no instance of the kind has occurred in those places. But yet in this, as in the former case, certain changes have taken place by reason of the manners and customs of the people. And these things are the more to be observed, because an idea has settled itself in the minds of men that a continual decline is going on, both in the length of life and the size and strength of the body, and that everything decays and deteriorates.[2]

24. Men generally live longer in cold and northern climates than in warm ones. And this must needs be; for the skin is tighter, the juices of the body less easily dissipated, the spirits less eager to consume and more easily repaired, and the air, as being only slightly warmed by the sun's rays, less predatory. But below the equinoctial line, where there are two summers and two winters, and a greater equality in the lengths of day and night, men likewise (if nothing else prevents them) live to a considerable age, as in Peru and Ceylon.[3]

25. Islanders generally live longer than those that live on continents. Men do not live so long in Russia as in the Orkneys, nor so long in Africa, though in the same latitude, as in the Canaries and Azores. The Japanese likewise live longer than the Chinese, though the latter have a mania for long life. And in this there is no wonder, seeing the sea-breeze warms and cherishes in cold countries, and cools in hot.

[1] Virg. Georg. i. 497.: "Grandiaque effossis mirabitur ossa sepulcris."
[2] Pliny, vii. 17.
[3] Pliny, vii. 2.

26. Inhabitants of high places live longer than of those which lie low; especially if they are not the tops of hills, but lands generally elevated, like Arcadia in Greece, and part of Ætolia, where the natives were very long-lived. The same would hold good of mountains themselves, because of the greater clearness and purity of the air, if it were not for an accident; namely, that the air is tainted by the vapours rising from the vallies and resting there. Among the snow-mountains therefore no remarkable longevity is found; not in the Alps, nor the Pyrenees, nor the Apennines; but on the lower hills and even in vallies men are more long-lived. However, on the tops of the mountains running towards Ethiopia and Abyssinia, where, as the soil consists of sand, little or no vapour settles on the mountains, men are very long-lived, and even at this day often complete 150 years.

27. Marshes and fens, especially if they are flat, are favourable to natives, but prejudicial to strangers, as far as longevity is concerned. And what may appear strange, salt marshes which are covered at high water are less healthy than those of fresh water.

28. The particular countries remarkable for the longevity of their inhabitants are Arcadia, Ætolia, India on this side of the Ganges, Brazil, Ceylon, Britain, Ireland, the Orkneys, and the Hebrides. As for that which is said by one of the ancients, that the Ethiopians were long-lived, it is report of no value.[1]

29. The salubrity of the air, especially in any degree of perfection, is a mysterious thing, and better discovered by experiment than by discourse and conjecture. The experiment may be tried by a lock of

[1] Pliny, vii. 2. Herod. iii. 23.

wool, if, on being exposed for a few days to the open air, it loses little weight; or by a piece of meat remaining long fresh; or by the water in a thermometer rising and falling through a small space. Of these things and the like make further inquiry.

30. The equality of the air, as well as the goodness and purity, is important for longevity. Variety of hill and valley, though pleasant to the eye and the sense, is suspected with regard to longevity; but a plain moderately dry, yet not too barren or sandy, nor entirely devoid of trees and shade, is most adapted to long life.

31. Inequality of the air, as has been just now said, is bad for dwelling in; but change of air in travelling, when one is accustomed to it, is good, and therefore great travellers have been long-lived. So likewise men who have passed their whole lives in the same cottage or on the same spot, are long-lived. For the air to which a man is accustomed is less predatory; but change of air is more nourishing and restoring.

32. Though it has been observed that the continuation and number of generations have nothing to do with the length and shortness of life, yet the immediate condition of the parents, both on the father's and mother's side, is doubtless very important. Some are begotten by old men, some by young, and some by men in the prime of life; some when their fathers are healthy and well-disposed, others when weak and sickly; some when full or drunk; others after sleep, or in the morning; some again after a long intermission, and others after a frequent repetition of the conjugal act; some (as generally in the case of bastards) in the heat of passion, others when desire begins to cool, as in the case of long-married couples. The same things must

be considered on the mother's side, together with her condition, health, and diet while she is with child, and the time of gestation, whether it be ten months or less. To reduce all this to a rule for longevity is difficult, and the more so because what a man would think best may perhaps prove the worst. For that alacrity in generation which produces children strong and active will have a tendency to stop longevity, by reason of the acrimony and inflammation of the spirits. I have before observed, that to have more of the mother's blood contributes to longevity; and in like manner I suppose everything in moderation to be the best; conjugal affection to be better than meretricious; the morning to be the best time for generation; and a state of body not too lusty and full, and the like. It should also be well observed that a robust habit of body in the parents is better for them than for the child, especially in the mother. Plato therefore judged wrongly that the virtue of generations was impaired, because women did not use the same mental and bodily exercises as men.[1] For the contrary is true, and the difference of strength between the male and female is most beneficial to the child; and the more delicate or tender the mother or nurse is, the more nourishment does she afford to the child. The Spartan women, who did not marry before twenty-two (or twenty-five, according to some[2]), and were therefore called Andromanæ, did not produce a nobler or more long-lived offspring than the Roman, Athenian, or Theban women did, who were marriageable at twelve or fourteen. And if there was anything remarkable in the Spartans, it was rather due to their simple living than to the late marriage of the

[1] Plato, Rep. v. § 3. [2] Plutarch, Comp. Lycurg. cum Numa, i. p. 77.

women. But experience shows, that some families are for a time long-lived; so that longevity, like diseases, is for certain periods hereditary.

33. Persons of fair complexion, skin, and hair, are less long-lived than those who are dark, red, or freckled. Too high a colour in youth is not so good a sign of longevity as paleness. A hard skin is better than a soft one; and herein I do not mean that thick and spongy skin, called the goose-skin, but one which is both hard and close; and a deep wrinkled brow is a better sign than a smooth and shining one.

34. Rough and bristly hair gives a better prospect of long life than that which is soft and delicate. Curls also, if they be stiff, indicate the same; but the contrary if soft and glossy. Likewise thick curls are better than long locks.

35. Early or late baldness is a thing immaterial; for many bald men have been long-lived. Nor are early grey hairs (though they appear to be the precursors of old age) any sure sign; for many who have turned grey early have lived late. Nay, premature greyness without baldness is a sign of longevity; but the contrary if it be attended with it.

36. Hairiness of the upper parts of the body is a sign of short life; and men with hairy breasts, like manes, are short-lived; but hairiness in the lower parts, as the thighs and legs, indicates longevity.

37. Tallness of stature (unless it is excessive), in a body well made and not too slender, but especially if it is accompanied by activity, is a sign of long life. But, on the contrary, men of short stature live longer, if they are less active, and slower of motion.

38. With regard to the proportion of the body;

those who are short in the body but long in the legs live longer than those who are long in the body and short in the legs. So likewise, those who are wider below and narrower above, the body rising as it were to a point, are more long-lived than men with broad shoulders, who taper downwards.

39. Leanness, if the passions are settled, calm, and easily controlled; or a full habit, if they be choleric, excitable and obstinate, betoken a long life. In youth corpulency foreshows an early death, but in old age it is more indifferent.

40. To grow long and slowly is a sign of longevity, and the taller the stature the better the sign. But, on the other hand, rapid growth to a great stature is a bad sign, but to a shorter stature less bad.

41. Firmness of flesh, a muscular and sinewy body, buttocks not spread out more than is required for sitting, and veins somewhat prominent, indicate a long life; the contrary to these a short one.

42. A head small in proportion to the body; a moderate-sized neck, neither too long and slender, nor too thick and sunk into the shoulders; wide nostrils, whatever the form of nose; a large mouth; ears gristly, not fleshy; teeth strong and close set, not weak and scanty, are signs of long life; and much more so if new teeth come late in life.

43. A broad chest, but rather drawn in than prominent; shoulders somewhat round and bowed (as they call it); a flat stomach; a large hand, with few lines in the palm; a short round foot; thighs not very fleshy; and a calf not drooping but firm, are signs of longevity.

44. Eyes rather large, with an iris of a greenish

colour; senses not too acute; a pulse slow in youth, but quicker as age increases; a power of holding the breath easily and long; the bowels more costive in youth, and looser in old age, are likewise all signs of longevity.

45. On the connection between longevity and the times of nativity nothing has been observed worth recording, except some astrological observations which I dismissed in the Topics. An eight months' child is deemed not only not long-lived, but not likely to live. Children born in the winter are considered to live long.

46. A Pythagorean or monastic diet according to the stricter rules, or one exactly regulated like that of Cornaro, seems to have a strong tendency to prolong life. Yet on the other hand, of such as live freely and in the common way, the greatest gluttons, and those most devoted to good living, are often found the most long-lived. The middle diet, which is esteemed temperate, is commended, and contributes to health, but not to longevity. For the stricter diet generates few spirits, and those of a sluggish nature, which consume the body less; and the freer diet affords abundant nourishment, which restores the body more; but the middle diet does neither. For where extremes are prejudicial, the mean is the best; but where extremes are beneficial, the mean is mostly worthless. But the strict diet likewise requires watching, lest the spirits being few should be oppressed by too much sleep; little exercise, lest they should be discharged; and chastity, lest they should be exhausted. But the full diet on the contrary requires plenty of sleep, frequent exercise, and seasonable use of venery. Baths and ointments such as have been in use are more suited for luxury

than the prolongation of life. But all these subjects I will discourse of more fully when I come to inquire of intentions. In the mean time we should not neglect the advice of Celsus,[1] a wise as well as a learned physician, who advises variety and change of diet, but with an inclination rather to the liberal side; namely, that a man should at one time accustom himself to watching, at another to sleep, but oftener to sleep; sometimes fast and sometimes feast, but oftener feast; sometimes strenuously exert, sometimes relax the faculties of his mind, but oftener the latter. But doubtless a well-regulated diet most contributes to the prolongation of life; and I never met a very old man, who on being asked had not observed some peculiarity of diet; some one thing, some another. I remember an old man above a hundred, being brought as a witness about some ancient prescription, who when at the end of his evidence he was familiarly asked by the judge, "what means he had taken to live so long," answered unexpectedly, and amidst the laughter of the audience, "By eating before I was hungry, and drinking before I was thirsty." But of these things (as I said) I will speak hereafter.

47. A life spent in religious and holy offices seems to contribute to longevity. This kind of life is attended with leisure, admiration and contemplation of heavenly things, pure joys, noble hopes, salutary fears, sweet sorrows, and lastly, continued renewals, by observances, penances and atonements, which have all a strong tendency to prolong life. And if besides these there is a strict diet to harden the substance of the body, and lower the spirits, no wonder if remarkable

[1] Celsus, i. 1.

longevity ensue; like that of Paul the Hermit, Simeon Stylites the columnar anchorite, and many other hermits and anchorites.

48. Next to this life comes that of letters, as that of the philosophers, rhetoricians, and grammarians. Here also life is passed in leisure, and in meditations which, having no relation to the affairs of life, breed no anxiety, but delight by their variety and freedom. These men live as they please, passing their days and hours in the things they like best, and mostly in the company of youth, which is more cheerful. But there is a great difference in the longevity of philosophers, according to their different tenets. The best philosophies for the purpose are those which have some touch of superstition, and deal with sublime contemplations, as the Pythagorean and Platonic; those likewise which comprised within themselves the survey of the universe, the variety of nature, unbounded, deep and noble thoughts concerning the infinite, the stars, the heroic virtues, and the like, were good, as were those of Democritus, Philolaus, Xenophanes, the astrologers and the stoics; and so were those which contained no deep speculation, but from common sense and common opinions discussed questions calmly on either side, without any laborious inquiry. Such were the sects of Carneades and the academicians, the rhetoricians and grammarians. But on the other hand, philosophies dealing with troublesome subtleties, dogmatic, weighing and wresting everything to the standard of certain principles; and lastly, those that were crabbed and narrow, were bad; and such were mostly the sects of the peripatetics and schoolmen.

49. A country life is likewise adapted to longevity.

It is much out of doors and in the open air, not indolent but active, living generally on fresh and home-made food, and free from care and envy.

50. I have also a good opinion of a military life in youth. Many famous warriors have certainly been long-lived, as Corvinus, Camillus, Xenophon, Agesilaus, and many others both ancient and modern. And it doubtless tends to longevity to have all things growing smoother and easier as age comes on: so that a youth spent in toil may sweeten old age. The military passions likewise, excited in the desire for contest and the hope of victory, appear to me to infuse such a warmth into the spirits as is advantageous to longevity.

MEDICINES FOR THE PROLONGATION OF LIFE.

In connection with the 10th Article of Inquiry. Transition.

The present system of medicine only regards the preservation of health and the cure of diseases; but of the things that properly relate to longevity it makes little mention, and only by the way. I will however set forth the medicines of note in this kind, namely, those that are called "cordials." For it is probable that remedies taken to defend and fortify the heart, or more correctly the spirits, against poisons and diseases, may, if judiciously selected and transferred to diet, tend likewise in some degree to prolong life; and in doing this I will not heap them promiscuously together, as is usually done, but select the best.

1. Gold is used in three forms; either in what is called potable gold, or in wine in which gold has been quenched, or in substance, as gold leaf and filings.

With regard to potable gold, it is now given as a strong cordial in dangerous or desperate maladies with tolerable success. But it appears to me that the spirits of salt by which the solution is made, rather than the gold itself, supplies the virtue that is found therein; but this is carefully suppressed. Now if gold could be opened without corrosive waters, or by corrosive waters (provided they had no poisonous qualities) that were afterwards well washed, I conceive it would be a useful thing.

2. Pearls are taken, either in a fine powder or in a kind of paste or solution made by the juice of very sour and fresh lemons. Sometimes they are given in aromatic confections, sometimes in a fluid form. Pearls no doubt have some affinity with the shells wherein they grow, and perhaps may have nearly the same qualities as the shells of crawfish.

3. Of crystals two are chiefly regarded as cordials, the emerald and the jacinth; which are given in the same forms as pearls, excepting that, as far as I know, their solutions are not used. But I am somewhat suspicious of these glassy jewels, by reason of their roughness.

Admonition. I will mention afterwards how far and in what manner these things here mentioned may be used with advantage.

4. Bezoar stone is of approved virtue for refreshing the spirits and raising a gentle perspiration. The unicorn's horn has lost its reputation, yet it still stands as high as hartshorn, the bone of the stag's heart, ivory, and the like.

5. Ambergris is one of the best things for soothing and comforting the spirits. Here follows an enumeration of the simple cordials, by name only: their virtues being sufficiently known.

Hot. Saffron: folium Indum: lignum aloes: citron rind: balm: basil: clove gillyflowers: orange flowers: rosemary: mint: betony: carduus benedictus.

Cold. Nitre: roses: violets: strawberry plants: strawberries: the juice of sweet lemons: the juice of oranges: the juice of apples: borage: bugloss: burnet: sandal-wood: camphire.

Admonition. As I am now discoursing only of those medicines which may be transferred into diet, all strong waters and chemical oils (which as some trifler says lie under the planet of Mars, and have a violent and destructive power), nay, all acrid and pungent spices, are to be rejected; and it should be observed how waters and fluids may be compounded from the preceding simples; not phlegmatic distilled waters, nor on the other hand burning waters from spirits of wine, but such as are more temperate, yet lively, and emitting a grateful vapour.

6. I am in some doubt whether frequent bleeding tends to longevity; but I rather incline to believe that it does, if it be turned into a habit, and other things are favourable thereto. For it discharges the old juices of the body and lets in new.

7. Some wasting diseases likewise, if well cured, do in my opinion assist longevity. For the old juices being consumed they supply new ones; and as one says, "to

recover health is to renew youth." It would be well therefore to induce some artificial diseases, as is done by strict and emaciating diets, whereof I will speak hereafter.

THE INTENTIONS.

In connection with the 12th, 13th, and 14th Articles of Inquiry.

Transition.

Having now finished the inquiry according to the subjects, namely, inanimate bodies, vegetables, animals, and man, I will draw nearer to the matter and commence an inquiry according to intentions; such as I fully believe to be true and proper, and as it were the pathways of mortal life. In this part nothing of any value has been hitherto inquired; and men's thoughts concerning it have been superficial and unprofitable. For when on the one side I hear men talk of comforting the Natural Heat, and the Radical Moisture, of meats which breed good blood, that is, neither burning nor phlegmatic, and of the reviving and refreshment of the spirits, I suppose them to be well meaning men who talk thus; but none of these things are effectual for the end. But when on the other side I hear discourses on medicines prepared from gold (because forsooth gold is not subject to corruption); on the use of precious stones to refresh the spirits, by reason of their secret properties and brilliancy; that if balsams and the quintessences of living creatures could be received and detained in vessels, there would be good hope of immortality; that the flesh of serpents and deer by a kind of sympathy have power to renew life, because the one casts its slough, the other its horns (they should have added likewise the flesh of the eagle, for the eagle casts its beak); that a certain man who found

an ointment buried in the earth, and anointed himself therewith from head to foot, excepting only the soles of his feet, lived in consequence 300 years, free from all disease, except swellings on the soles of his feet; that Artefius, when he felt his spirit failing, drew into himself the spirit of a strong young man, thereby killing him, but continuing his own life for many years by means of that other man's spirit; when I hear of fortunate hours, according to the figures of heaven, in which medicines for the prolongation of life are to be collected and prepared; of planetary seals by which virtues may be extracted and brought down from heaven to prolong life, and such like fables and superstitions, I wonder exceedingly that men should be so demented as to be imposed upon by them. Lastly, I pity the hard fortune of mankind in being surrounded on all sides by things frivolous and unprofitable. With regard to my own Intentions, I trust that they both come close to the point, and are far removed from idle and credulous superstitions; being likewise, I conceive, of such a nature that while posterity may add much to the things which satisfy these intentions, they will find little to add to the intentions themselves.

There are however a few things that are yet of great importance, whereof I would have men forewarned.

First, I am of opinion that the duties of life are preferable to life itself. Wherefore, if there be anything which may exactly answer our intentions, yet interferes at all with the offices and duties of life, I reject it. I may perhaps make some light mention of things of this kind, but I by no means insist upon them. For I do not enter into any serious or accurate discourse either of living in caves, like the cave of

Epimenides, where the sunbeams and changes of temperature never penetrate; or of perpetual bathing in prepared liquors; or of shirts and cerecloths so applied that the body should always be in a kind of case; or of thick covers of paint on the body, after the manner of savages; or of that exact regulation of food and diet which makes the preservation of life its sole object, to the neglect of everything else (such as that of Herodicus among the ancients,[1] and Cornaro of Venice in our days, though with more moderation); or of any such strange, nice, and inconvenient matters. But I prescribe such remedies and precepts as will neither prevent the duties of life, nor hinder and embarrass them too much.

Secondly, on the other hand, I warn men to give up trifling, and not to imagine that so great a work as the stopping and turning back of the powerful course of nature can be performed by a morning draught, or the use of some precious drug; but to consider it certain that a work of this kind must necessarily be very laborious, and consist of many remedies, and those aptly connected with one another. For no man can be so dull as to believe that what has never yet been done can be done, except by means hitherto unattempted.

Thirdly, I candidly admit that some of the propositions here laid down have not been proved by experiment (for my course of life permits not of that), but are only derived, with what appears to me the best reason, from my principles and hypotheses (whereof I insert some and reserve others in my mind), and as it were cut and dug out of the rock and mine of nature herself. Yet I have not been careless, but (seeing that

[1] Plato, Rep. iii.

I was dealing with the body, whereof the Scripture says that it is above raiment), have used all prudence and circumspection in propounding such remedies, as, if by chance they are not fruitful, are at least safe.

Fourthly, I would have men duly to observe and distinguish that the same things which conduce to health do not always conduce to longevity. For some things which are of use to cheer the spirits and to strengthen and invigorate the functions, yet take away from the sum of life. Again, there are other things very beneficial in prolonging life, yet that are not without danger to the health unless guarded against by proper means. On these points however, as occasion requires, I will not neglect to exhibit proper cautions and admonitions.

Lastly, I have thought it right to propose sundry remedies, according to each intention, but the choice and order thereof to leave to discretion. For to describe exactly the things most suitable to the different constitutions of bodies, to the different kinds and respective ages of life, in what order they are to be taken, and how their whole practice is to be administered and governed, would be too long a work, and unfit to be published.

In the Topics I propounded three Intentions; namely, the Prevention of Consumption, the Perfecting of Repair, and the Renovation of Decay. But seeing that what I am about to say is something more than mere words, I will draw out these three Intentions into ten Operations: —

1. The first operation is upon the spirits, to renew their freshness.

2. The second operation is upon the exclusion of air.

3. The third operation is upon the blood, and the sanguefying heat.

4. The fourth operation is upon the juices of the body.

5. The fifth operation is upon the bowels, for the extrusion of aliment.

6. The sixth operation is upon the outer parts of the body, for the attraction of aliment.

7. The seventh operation is upon the aliment itself, for the insinuation thereof.

8. The eighth operation is upon the final act of assimilation.

9. The ninth operation is upon the inteneration of the parts after they have begun to dry.

10. The tenth operation is upon the purgation of the old juice, and the substitution of new.

Of these operations the four first belong to the first intention, the four next to the second, and the two last to the third.

But as this part concerning Intentions points to practice, under the title of history I will include not only experiments and observations, but also counsels, remedies, explanations of causes, assumptions, and all things relating thereto.

I.

THE OPERATION UPON THE SPIRITS, THAT THEY MAY RETAIN THEIR YOUTH AND RENEW THEIR VIGOUR.

The History.

1. The spirits are the agents and workmen that produce all the effects in the body. This appears manifest both by general consent and by innumerable instances.

2. If it were possible for young spirits to be put into an old body, it is probable that this great wheel might put the lesser wheels in motion, and turn back the course of nature.

3. In every kind of consumption, whether by fire or age, the more the spirit of the thing, or the heat, preys upon the moisture, the shorter is the duration of that thing. This occurs everywhere, and is plain.

4. The spirits are to be put into such a temperament, and such a degree of activity that (as one says) they shall not drink and absorb, but only sip the juices of the body.

5. There are two kinds of flames; the one active but weak, as the flame of straw or chips, that consumes and discharges lighter substances, but has little effect upon the harder; the other strong and steady, as the flame of large timber and the like, which attacks likewise hard and tough bodies.

6. The brisk and yet weak flame dries up bodies, and makes them effete and sapless; whilst the strong flame softens and melts them.

7. Of dissipating medicines, some only draw forth the thinner parts of tumours, and thereby harden them; but some discuss them vigorously, and thereby soften them.

8. Of purging and clearing medicines likewise, some carry suddenly off the more fluid parts, and some draw the more obstinate and viscous.

9. The spirits should be clad and armed with such a heat that they may prefer rather to pluck asunder and undermine the hard and obstinate parts, than to discharge and carry off such as are weak and prepared; for by this means the body becomes fresh and firm.

10. The spirits should be so tempered and ordered, as to become in substance dense, not rare; in heat lasting, not eager; in quantity sufficient for the offices of life, not redundant or excessive; in motion settled, not starting or irregular.

11. Vapours evidently operate powerfully upon the spirits; as is shown by sleep, intoxication, melancholy and mirthful passions, and recovery of the spirits in swoons and fainting-fits by odours.

12. The spirits are condensed in four ways; by putting them to flight, by cooling, by soothing, or by quieting them. And first of their condensation by flight.

13. Whatever puts to flight from all sides drives the body to its centre, and therefore condenses.

14. Opium is by far the most powerful and effectual means for condensing the spirits by flight; and next to it opiates and soporifics in general.

15. The power of opium to condense the spirits is very remarkable; for perhaps three grains will in a short time so coagulate them that they cannot separate, but are quenched and rendered immoveable.

16. Opium and similar drugs do not put the spirits to flight by their coldness (for they have parts manifestly warm), but contrariwise they cool by putting the spirits to flight.

17. The flight of the spirits by means of opium and opiates is best seen when they are applied externally; for the spirits instantly retire and will return no more, but the part mortifies and turns to a gangrene.

18. Opiates give relief in great pain, as the stone, or amputation of a limb; principally by putting the spirits to flight.

19. Opiates draw a good effect from a bad cause; for the flight of the spirits is bad, but the condensation thereof by that flight is good.

20. The Greeks imputed much to opium, both for health, and prolongation of life; but the Arabs still more; so that their higher medicines (which they call "God's Hands") have opium for their basis and principal ingredient, with a mixture of other things to counteract and correct the noxious qualities thereof; such are treacle, mithridate, and the like.

21. All remedies successfully used in pestilential and malignant diseases to check and curb the spirits, lest they become unruly and turbulent, may be advantageously transferred to the prolongation of life. For the condensation of the spirits, which is best secured by opiates, is beneficial in both cases.

22. The Turks find opium, even in large quantities, innocent and cordial, so that they even take it before a battle to give them courage. But to us, except in small quantities, and with strong correctives, it is fatal.

23. Opium and opiates are clearly found to excite the sexual passion, which shows their power to strengthen the spirits.

24. Distilled water of the wild poppy being doubtless a mild opiate, is successfully given in surfeit, fevers, and various diseases; and let no one wonder at the variety of its use. For this is common to opiates, as the spirits being strengthened and condensed will fight against any disease.

25. The Turks use likewise a kind of herb, called "coffee," which they dry, grind to powder, and drink in warm water. They affirm that it gives no small vigour both to their courage and their wit. Yet this

taken in large quantities will excite and disturb the mind; which shows it to be of a similar nature to opiates.

26. There is a certain root, celebrated through all the East, called "betel," which the Indians and others use to carry in their mouths, and chew; whereby they are wonderfully refreshed, and enabled to endure fatigues, and throw off disorders, and strengthened for sexual intercourse. It appears to be a kind of narcotic, because it blackens the teeth exceedingly.

27. The use of tobacco has immensely increased in our time. It affects men with a kind of secret pleasure, so that persons once accustomed to it can scarce leave it off. It tends no doubt to relieve the body, and remove weariness; and its virtue is commonly thought to lie in this, that it opens the passages and draws off the humours. But it may be more properly referred to the condensation of the spirits; for it is a kind of henbane, and manifestly affects the head, as all opiates do.

28. Humours are sometimes generated in the body, which are a kind of opiates themselves; as is found in some kinds of melancholy, wherewith if a man be seized, he is very long-lived.

29. Simple opiates, which are likewise called narcotics and stupefactives, are opium itself, which is the juice of the poppy, the plant and seed of the poppy, henbane, mandragora, hemlock, tobacco, and nightshade.

30. Compound opiates are, treacle, mithridate, trifera, ladanum of Paracelsus, diacodium, diascordium, philonium, and pills of houndstongue.

31. From these observations certain directions or

advices may be drawn for the prolongation of life, according to this intention, namely, the condensing of the spirits by opiates.

32. From youth upwards, therefore, let there be every year a kind of opiate diet. Let it be taken at the end of May; for in summer the spirits are most wasted and weakened, and there is less fear of cold humours. Let the opiate be of a superior kind, not so strong as those in use, either as to the quantity of opium or to the proportion of very hot ingredients. Let it be taken in the morning between sleeps. Let the diet at the time be more simple and sparing, without wine, spices, or things that produce vapours. Let the medicine be taken only on alternate days, and be continued for a fortnight. Such directions appear to me to answer the intention satisfactorily.

33. Opiates may not only be taken through the mouth, but likewise inhaled in the form of smoke; but it should be such as not to excite the expulsive faculty too strongly, nor draw out the humours, but only to work upon the spirits within the brain for a short time. Wherefore a suffumigation of tobacco, lign-aloes, dried leaves of rosemary, and a little myrrh, inhaled in the morning through the mouth and nostrils, would be very beneficial.

34. In the powerful opiates, as theriacum, mithridate, and the rest, it would not be amiss, especially in youth, to take the distilled waters rather than the bodies themselves. For in distillation the vapour rises, while the heat of the medicine generally settles; and distilled waters in the virtues conveyed by vapours are mostly good, in others weak.

35. Some medicines have a degree, weak and secret,

and therefore safe, of opiate virtue. These impart a slow and abundant vapour, but not malignant, as opiates do. And hence they do not put the spirits to flight, but yet they collect and somewhat thicken them.

36. The medicines that make opiates are, first of all saffron and its flowers; then Indian leaf, ambergris, a preparation of coriander seed, amomum and pseudamomum, lignum Rhodium, orange-flower water, or better still, the infusion of fresh orange-flowers in oil of almonds, nutmegs pricked full of holes and soaked in rose-water.

37. Though opiates, as has been mentioned, are to be used seldom and at certain times, yet this secondary kind may be taken frequently and in daily diet, and will conduce greatly to the prolongation of life. An apothecary of Calicut, by the use of amber, is said to have lived 160 years; and the nobles of Barbary, where the common people are short-lived, are found by a use of the same means to be long-lived. Our own ancestors, who were longer-lived than we are, made great use of saffron, in cakes, broths, and the like. And so much for the first means of condensing the spirits; namely, by opiates and their subordinates.

38. I now come to inquire into the second way of condensing the spirits, namely by cold. For condensation is the proper work of cold; and it is done without any malignity, or unfriendly quality. The operation, therefore, is safer than by opiates, though somewhat less powerful, if used only at intervals, as opiates are. But then since it may be used in moderation familiarly and as a part of daily diet, it has much more power than opiates to prolong life.

39. Refrigeration of the spirits takes place in three ways; by respiration, by vapours, or by aliments. Of these the first is the best, but mostly out of our power; the second likewise is strong, and yet within our reach; the third is weak and circuitous.

40. Air clear and pure, that has nothing fuliginous in it before it is inhaled into the lungs, and not much exposed to the sun's rays, best condenses the spirits. Such air is found either on dry mountain tops, or on plains open to the wind, yet somewhat sheltered from the sun.

41. With regard to the refrigeration and condensation of spirits by vapours, the root of the operation I place in nitre, as a thing specially created for this purpose. To this opinion I am led by the following considerations.

42. Nitre is a kind of cold aromatic, as is apparent to the sense itself. For it bites and tries the tongue and palate with cold, as aromatics do with heat; and it is the only one, as far as we know, that does this.

43. Almost all cold things (at least all things cold properly, and not accidentally, as opium) have a weak and poor supply of spirit; and, on the other hand, things full of spirit are almost all hot. Nitre is the only body found in the vegetable world which abounds with spirit and yet is cold. For camphor, which is full of spirit, and yet produces the effects of cold, refrigerates only by accident; inasmuch as, being thin and without acrimony, it assists perspiration in inflammations.

44. In the practice of congealing and freezing fluids that has lately come into use, by applying snow and ice to the exterior of the vessel, nitre is also used, and no

doubt excites and strengthens the congelation. It is true that common bay salt is likewise used for this purpose, which rather supplies activity to the cold of the snow than gives a coldness itself; I have heard however that in hot countries, where there is no snow, congelation is produced by nitre alone; but this I have not proved.

45. Gunpowder, which consists principally of nitre, is said, when taken in a draught, to inspire courage, and to be often used by soldiers and sailors before a battle, as opium is by the Turks.

46. Nitre is successfully administered in burning and pestilential fevers to relieve and subdue their destructive heats.

47. Nitre in gunpowder has evidently a great aversion to flame, which causes that wonderful blast and explosion.

48. Nitre is found to be as it were the spirit of the earth. For it is most certain that any earth, though pure and unmixed with nitrous matter, if it be so laid up and covered as to be free from the rays of the sun, and produce no vegetable matter, will collect a great quantity of nitre. And from this it appears that the spirit of nitre is inferior, not only to the spirit of animals, but also to the spirit of vegetables.

49. Animals that drink nitrous water evidently grow fat, which is a sign of the cold in nitre.

50. Land is most enriched by nitrous bodies; for all manure is nitrous, which is a sign of the spirit in nitre.

51. From this it appears that the human spirits can be cooled and condensed by the spirit of nitre, and made more crude and less eager. As therefore strong

wines, spices, and the like, inflame the spirits and shorten life, so, on the other hand, nitre composes and restrains the spirits and tends to longevity.

52. Nitre may be taken in food with salt — ten parts of salt to one of nitre; or from three to ten grains may be mixed in morning broths or draughts. But in whatever way it is taken, if it only be in moderation, it is very beneficial to longevity.

53. As opium plays the principal part in condensing the spirits by flight, and has at the same time its less powerful but safer subordinates, which may be taken more frequently, and in greater quantity, as was before mentioned; so likewise nitre, which condenses the spirits by cold and (as they say now-a-days) by a kind of *frescour*, has its own subordinates.

54. All things which have a somewhat earthy smell, like the smell of pure and good earth, lately turned or dug, are subordinates to nitre. The principal of these are borage, bugloss, langue de bœuf, burnet, strawberry plants, strawberries, raspberries, raw cucumbers, raw apples, vine leaves, vine buds, and violets.

55. Next to these come those which have a certain freshness of smell, with a certain inclination to heat, yet not entirely devoid of that cooling property. Such are balm, green citrons, green oranges, distilled rose-water, roasted pears, and pale, red, and musk roses.

56. It should be observed that the subordinates of nitre further the intention better in a raw than in a cooked state; because that spirit of cooling is dissipated by fire. They are therefore best taken either infused in liquid, or raw.

57. In the same way as the condensation of the

spirit by the subordinates of opium is in some degree performed by smells, so likewise is that caused by the subordinates of nitre. Therefore the smell of the pure and fresh earth in following the plough, or digging or weeding, is an excellent composer of the spirits. Leaves falling in woods and hedges towards the close of autumn, and most of all dying strawberry leaves, supply a good coolness to the spirits. The smell of violets, wallflowers, bean-blossoms, sweet briar, and clary, taken while they are growing, is of a like nature.

58. I knew also a nobleman, who lived to a great age, who every morning, directly he awoke, had a clod of fresh earth placed beneath his nose for him to smell.

59. It is certain that the cooling and tempering of the blood by cold things, as endive, chicory, hepatica, purslane, and the like, do as a consequence cool the spirits also; but it is by a slow and indirect process, whereas vapours operate immediately.

So much then for the condensation of the spirits by cold. The third process of condensation was said to be by that which I call the soothing of the spirits; the fourth, by the quieting of their alacrity and over-activity.

60. All things soothe the spirits that are pleasing and friendly to them, and yet do not excite them too much to go forth; but contrariwise induce a state in which the spirits, being as it were contented with themselves, enjoy their own society, and betake themselves to their proper centre.

61. If you recollect the things before set down as

subordinates to opium and nitre, there is no need of further inquiry on this subject.

62. With regard to the quieting of the violence of the spirits, I will speak of it presently when I come to inquire concerning their motions. Now, therefore, having spoken of the condensation of spirits (which belongs to the substance of them), I come to the degree of heat therein.

63. The heat of the spirits should be, as was said, of that kind which is robust but not eager, and loves rather to undermine tough and obstinate parts than to carry off the weak and thin.

64. We must be cautious about spices, wine, and strong drink, and use them very temperately, with intervals of abstinence; and so likewise with regard to savory, marjoram, penny-royal, and all herbs which bite and burn the palate. For they supply to the spirits a heat not operative but predatory.

65. Those that yield a robust heat are principally elecampane, garlic, carduus benedictus, young watercress, germander, angelica, zedoary, vervain, valerian, myrrh, spikenard, elder flower, and chevril. The use of these with care and judgment, sometimes in food, sometimes in medicines, will satisfy this operation.

66. It is fortunate likewise that the grand opiates are also of great service to this operation, in that they yield by composition such a heat as is desired, but can scarce be obtained, from simples. For the introduction of those intensely hot things (as spurge, pellitory, stachys-agra, dragonwort, pistachio nut, castor oil, aristolochium, opopanax, ammoniac, gum resin, and the like, which cannot be taken internally by themselves), to counteract the narcotic power of opium,

constitutes that temper of medicine which is now required; as is well shown in this, that theriacum, mithridate, and the rest, are not acrid and do not bite the tongue, but have only a slight bitterness and a strong scent, and only betray their heat in the stomach, and in their subsequent operations.

67. The sexual appetite often excited, but seldom gratified, conduces likewise to this robust heat of the spirits; as also do some other passions, of which I will speak hereafter. And so much for the heat of the spirits in relation to the prolongation of life.

68. Of the quantity of the spirits, that they be not exuberant, and given to ebullitions, but rather stinted and moderate (for a small flame does not prey so much as a large one), the inquiry will be short.

69. It seems to be approved by experience that a spare and almost Pythagorean diet, such as is prescribed by the stricter orders of monastic life, or the institutions of hermits, which regarded want and penury as their rule, produces longevity.

70. To this kind of life belong water-drinking, a hard couch, cold air, a spare diet (that is, of herbs, fruits, flesh, and fish, potted and salted rather than fresh and hot), a hair shirt, frequent fastings, frequent watchings, few sensual pleasures, and the like. For all these diminish the spirits and reduce them to such a quantity as is only enough for the offices of life; whence their depredation is less.

71. But if the diet shall be a little more generous, and without so much rigour and mortification, yet so long as it is regular and consistent, it produces the same result. For in flames likewise we see that a somewhat greater flame, if it be steady and calm, consumes less

of its fuel than a smaller flame that is blown about, and alternately strong and weak. The regimen and diet of Cornaro of Venice has demonstrated this well, seeing that for so many years he ate and drank by exact weight, whereby he exceeded 100 years of age, with his strength and senses unimpaired.

72. We should likewise take care that a body fully nourished, and not reduced by any of these spare diets, does not neglect a seasonable use of sexual intercourse, lest the spirits grow too full, and soften and destroy the body. So much therefore for a moderate, and as it were frugal, quantity of spirits.

73. Next follows the inquiry for restraining the motions of the spirits; for motion evidently alternates and inflames them. This restraint is effected in three ways; namely, by sleep, by avoiding strong labour, too much exercise, and all fatigue, and by controlling uneasy affections. And first concerning sleep.

74. The story goes that Epimenides slept many years in a cave without needing any food; for in sleep the spirits are less predatory.

75. Experience tells us that some animals, as dormice and bats, sleep through the whole winter in holes and corners; such power has sleep to stop vital consumption. The same likewise is thought to be the case with bees and drones, though sometimes deprived of their honey; also with butterflies, and flies.

76. Sleep after dinner, wherein vapours not unpleasing (as being only the first dews of food) rise to the head, is good for the spirits, but bad and prejudicial to all other things that relate to the health. In extreme old age however the same principle holds with regard to food and sleep, for both should be taken frequently,

though little at a time. And at the very end of life, mere rest, and a kind of perpetual repose, is good, especially in the winter.

77. But as moderate sleep tends to longevity, so much more if it be calm and undisturbed.

78. The procurers of calm sleep are violets, lettuce (especially when boiled), syrup of dry roses, saffron, balm, apples eaten at bedtime, and a malmsey toast, especially if first infused in musk roses. It would be useful therefore to make up some pill or small draught of these compounds, and take it familiarly. Things likewise which close up firmly the mouth of the stomach, as a preparation of coriander seed, quinces, and roast pears, induce sound sleep. But above all for young men, and especially for those who have strong stomachs, a good drink of cold water at bedtime is beneficial.

Injunction. Of voluntary or procured trances, and of thoughts intent and profound (provided they are not uncomfortable), I know nothing certain. They contribute no doubt to this intention, and condense the spirits, even more powerfully than sleep; seeing they lull and suspend the senses as much, or even more. Of these make further inquiry. And so much for sleep.

79. With regard to motion and exercises; fatigue and all motion and exercise that is too rapid and violent, as running, games at ball, fencing, and the like, are injurious; as also those exercises in which our strength is exerted and strained to the uttermost, as leaping, wrestling, and the like. For it is certain that the spirits being distressed either by swiftness of the

motion or extreme efforts, become afterwards more active and predatory. On the other hand, exercises which provoke a motion tolerably strong, yet not too rapid, or requiring the uttermost strength, such as dancing, archery, riding, playing at bowls, and the like, are not injurious but rather beneficial.

I now come to the affections and passions of the mind, to see which of them are prejudicial to longevity, which profitable.

80. Great joys attenuate and diffuse the spirits, and shorten life; ordinary cheerfulness strengthens the spirits, by calling them out, and yet not wasting them.

81. Sensual impressions of joys are bad; ruminations of joys in the memory, or apprehensions of them in hope or imagination, are good.

82. Joy suppressed and sparingly communicated comforts the spirits more than joy indulged and published.

83. Grief and sadness, if devoid of fear, and not too keen, rather prolong life; for these contract the spirits, and are a kind of condensation.

84. Great fears shorten life. For though both grief and fear distress the spirit, yet grief causes only a simple contraction; whereas fear, through cares respecting the remedy and hopes intermixed, causes a turmoil and vexation of the spirits.

85. Suppressed anger is likewise a kind of vexation, and makes the spirit to prey upon the juices of the body. But anger indulged and let loose is beneficial, like those medicines which induce a robust heat.

86. Envy is the worst passion, and preys on the spirits, which again prey on the body. And it is so much

the worse, because it is always at work, and (as they say) keeps no holidays.

87. Compassion for another man's misfortune, which does not appear likely to befall ourselves, is good. But that which may by some similitude be reflected on the person pitying is bad, because it excites fear.

88. A light shame hurts not, because it slightly contracts the spirits and then diffuses them; and therefore bashful persons are generally long-lived. But shame for a great disgrace, and of long continuance, contracts the spirits even to suffocation, and is pernicious.

89. Love, if not unfortunate, and too deeply wounding, is a kind of joy, and is subject to the same laws as were laid down for joy.

90. Hope is of all affections the most useful, and contributes most to prolong life, if it be not too often disappointed, but feed the imagination with the prospect of good. They therefore who set up and propose some definite end as their mark in life, and continually and gradually advance thereto, are mostly long-lived; insomuch that when they arrive at the summit of their hopes, and have nothing more to look forward to, they commonly droop and do not long survive; so that hope appears to be a kind of *leaf-joy*, which may be spread out over a vast surface like gold.

91. Admiration and light contemplation are of very great effect in prolonging life. For they detain the spirits on pleasing subjects, and do not permit them to become tumultuous, unquiet, and morose. And hence all contemplators of nature, who had so many and such great wonders to admire, as Democritus, Plato, Parmenides, and Apollonius, were long-lived. The rhetoricians likewise, who did but taste matters lightly, and

busied themselves rather about light of speech than the darkness of things, as Gorgias, Protagoras, Isocrates, and Seneca, were long-lived. And certainly as old men are generally talkative and garrulous, so talkative persons very often grow to a great age; for it betokens a light contemplation, and one that does not greatly distress or vex the spirits; whereas subtle, acute, and eager inquisition shortens life; for it fatigues and preys upon the spirits.

So much then for the motion of the spirits by the affections of the mind. But I will add some other general observations on the spirits, which do not fall under the preceding division.

92. Particular care should be taken that the spirits are not too often dissolved. For attenuation precedes dissolution, and the spirit once attenuated is not easily recovered again and condensed. Dissolution is caused by too great labours, too violent affections of the mind, too profuse perspirations, too large evacuations, warm baths, and intemperate or unseasonable gratification of lust; also by too many cares and disquietudes, and anxious expectations; and lastly by malignant diseases, and severe pains and anguish of the body. All which should (as indeed the common physicians advise) be as far as possible avoided.

93. The spirits are delighted both with things accustomed, and with things new. But it contributes wonderfully to preserve the vigour of the spirits if we neither use customary things till they glut, nor new things before we feel a lively and vigorous appetite for them. Care and judgment therefore should be em-

ployed to break off customs before they become tiresome; and to curb the desire of new things for a season till it becomes more strong and quick. Moreover, the course of life should, if possible, be so ordered that it may have many and various restorations; and the spirits may not grow torpid by perpetual intercourse with the same things. For though Seneca[1] said well, "A fool is always beginning to live," yet this folly, like many others, contributes to longevity.

94. It is to be observed with regard to the spirits (although the contrary course be commonly followed), that when men perceive their spirits to be in a good, calm, and healthy state (which may be known by a quiet and cheerful disposition of mind), they should cherish and not change them; but if the spirits are in a disturbed and untoward state (as will be shown by sadness, heaviness, and other indisposition of mind), they should at once subdue and alter them. Now the spirits are continued in the same state by restraint of the affections, temperance of diet, abstinence frem sexual intercourse, refraining from labour, and moderate rest. They are overpowered and altered by the contrary; namely, by violent affections, profuse feasting, immoderate indulgence of the sexual appetite, arduous labours, intense study, and business. It is however the common practice of men, when they are the most merry and best disposed, to apply themselves most to feasting, love, labour, contentions, and business. But if a man should wish for long life, he ought (though it may seem strange) to adopt the contrary system; for good spirits should be cherished and continued, spirits ill disposed should be discharged and altered.

[1] Sen. Ep. 13.

95. Ficinus says well, "That old men, to comfort their spirits, should frequently recall and ruminate on the acts of their childhood and youth."[1] Such remembrance is no doubt the peculiar recreation of all old men; and hence it is that they delight in the society of their old schoolfellows, and love to visit the places of their education. Vespasian indeed had this feeling so strong, that when he was emperor he could no way bring himself to change his father's house, humble though it was, lest he should lose sight of familiar objects and the recollection of his boyhood. Nay, he used on holidays to drink out of a wooden cup, tipped with silver, which had belonged to his grandmother.[2]

96. The thing above all others most pleasing to the spirits is a continual advance to the better. Youth and manhood should therefore be so ordered as to leave new comforts for old age, whereof the principal is moderate rest. And therefore old men in honourable places who do not retire to a life of leisure, offer violence to themselves. A remarkable instance of this is found in the case of Cassiodorus, who had so much authority with the Gothic kings of Italy that he appeared to be the soul and life of their affairs; yet afterwards, when nearly eighty years of age, he retired into a monastery, where he lived to be a hundred. Herein, however, two cautions are required; one, that they do not wait till the body is entirely worn out and diseased, for in such bodies all change, even for the better, accelerates death; the other, that they do not give themselves up to mere inertness, but have something to entertain the minds and thoughts in a quiet way;

[1] Ficinus, De Vit. Prod. 8. [2] Sueton. in Vesp. 2.

for which the best kind of amusement is reading, and next building and planting.

97. Lastly, the same action, endeavour, and labour, which if undertaken cheerfully and with good will refreshes the spirits, if it be attended with aversion and dislike preys upon and prostrates them. It will therefore promote longevity if a man either so arrange his life that it shall be free, and pass as he likes, or else obtain such command over his mind that, whatever necessity fortune may impose, it may rather lead than drag him.

98. Nor must it be forgotten, as bearing on the government of the affections, that especial care is to be paid to the mouth of the stomach, chiefly to prevent it from being too much relaxed. For this part has more power over the affections, especially the daily ones, than either the heart or the brain; excepting only such as are caused by powerful vapours, as in drunkenness and melancholy.

99. So much then for the operation upon the spirits, that they may retain their youth and renew their freshness; which I have paid the more attention to, because physicians and other authors are mostly silent on these operations; but principally because the operation upon the spirits for the renewal of them is the easiest and most compendious way to the prolongation of life. And it is most compendious for two reasons; the one, because the spirits act compendiously on the body; the other, because vapours and affections act compendiously on the spirits; so that these go to their end as it were in a straight line, other things more circuitously.

II.

THE OPERATION UPON THE EXCLUSION OF THE AIR.

The History.

1. Exclusion of the external air tends in two ways to prolong life. First, because most of all things, next to the internal spirit, the external air (although it is as life to the human spirit, and contributes very much to health) preys upon the juices of the body and hastens its desiccation; whence the exclusion of the air conduces to longevity.

2. The second effect of the exclusion of the air is much more deep and subtle; namely, that the body being closed up, and not perspiring, detains the spirit within, and turns it upon the harder parts of the body, which are thereby rendered soft and tender.

3. The reason of this process is explained in the desiccation of inanimate bodies. And it may be taken for an infallible axiom, that the emission of the spirit dries bodies, but the detention thereof melts and softens them. And it may be further assumed that all heat properly attenuates and moistens, but contracts and dries only by accident.

4. A life in caves and holes, where the rays of the sun do not enter, may perhaps tend to longevity; for the air of itself, unexcited by heat, has not much power to prey upon the body. Certainly, on looking back, it appears from many remains and monuments that the size and stature of men were anciently much greater than they have been since, as in Sicily and some other places; and such men generally lived in caves. Now there is some affinity between length of

age and largeness of limbs. The cave of Epimenides likewise passes current among the fables. And I suspect that the life of the columnar anchorites was something like the life in caves, for there neither the rays of the sun penetrated, nor did the air admit of great changes or inequalities. It is certain that both the Simeons, Daniel Saba, and other stylites, were very long-lived. Modern anchorites likewise, shut up within walls or pillars, are often found long-lived.

5. Next to the life in caves is the life on mountains. For as the heat of the sun does not penetrate into caves, so on the tops of mountains, where there is no reflection, it has less power. But this must be understood of mountains where the air is clear and pure; that is, where from the dryness of the vallies mists and vapours do not ascend; as in the mountains that surround Barbary, where, even at the present day, men often live 150 years, as I have observed before.

6. Now air of this kind in caves and mountains has of its own nature little or no predatory power. But air such as ours is, rendered predatory by the heat of the sun, should as much as possible be excluded from the body.

7. The air is kept off and excluded in two ways; first, by closing the pores; secondly, by filling them up.

8. Closing of the pores is assisted by coldness of the air itself, by nakedness, which hardens the skin, by washing in cold water, and by astringents applied to the skin, as mastich, myrrh, and myrtle.

9. But this operation will be much better served by baths, seldom used however (especially in summer), consisting of such astringent mineral waters as may be

safely applied; such as chalybeate and vitriol waters; for these powerfully contract the skin.

10. As for filling up the pores, paints and such like thick unctuous substances, and (which may be most conveniently used) oil and fat things, no less preserve the substance of the body than oil colours and varnish preserve wood.

11. The ancient Britons painted themselves with woad, and were extremely long-lived. The Picts likewise had the same custom, and are even supposed by some to have derived their name from it.

12. At this day the natives of Brazil and Virginia use to paint themselves, and are said, especially the former, to be very long-lived; insomuch that five years ago the French Jesuits met with some of them who remembered the building of Fernamburg, which happened 120 years before, they being then grown up.

13. Johannes de Temporibus, who is said to have reached the age of three hundred, on being asked how he had preserved himself, is reported to have answered, "By oil without, and honey within."

14. The Irish, especially the wild Irish, are, even to this day, very long-lived. In truth, they say that within these few years the Countess of Desmond lived to 140, and shed her teeth three times. Now the Irish have a custom of standing naked before the fire, and rubbing and as it were pickling themselves with old salt butter.

15. These same Irish are accustomed to wear shirts and linen rubbed with saffron, which, though it was introduced to prevent putrefaction, yet I consider tends to lengthen life. For saffron is the best thing I know for the skin, and to comfort the flesh, seeing it is a

wonderful astringent, and has besides an oiliness and subtle heat without any acrimony. Indeed I remember an Englishman who, on crossing the Channel with a bag of saffron, to avoid paying duty, carried it for concealment around his stomach, and although before he had always been very sea-sick, he was this time quite well and felt no nausea.

16. Hippocrates[1] advises to wear clean clothes next to the skin in winter, but foul and smeared with oil in summer. The reason whereof appears to be, that in summer the spirits exhale most, and therefore the pores of the skin should be stopped.

17. I judge therefore that to anoint the skin externally with oil, either of olives or sweet almonds, contributes above everything to longevity. The anointing should take place every morning on rising; the oil should be mixed with a little bay salt or saffron. It should be done lightly with wool or a soft sponge, so as not to drop upon the body, but only to touch and moisten the skin.

18. It is certain that all liquids, even those of an oily nature, if in large quantities, draw something out of the body; but, on the other hand, in small quantities they are absorbed by the body. The anointing therefore, as I said, should be light, or the shirt itself should be smeared with oil.

19. It may perhaps be objected that this anointing with oil here recommended (though it has never been used by ourselves, and has been left off by the Italians) was formerly familiar to the Greeks and Romans, and part of their diet; and yet they were not more long-lived than the men of this age. But to this it may be

[1] Hippocr. de Salubri Diæta.

justly answered, that oil was only used after bathing, except perhaps by the athletes; and hot baths are as contrary to this operation as anointings are favourable to it; for the former opens while the latter closes the pores. Baths therefore, without subsequent anointing, are very bad; but anointing without bathing very good. Besides, this anointing was practised rather as a luxury, or (to view it in its best light) for the sake of health; and with no relation to longevity. Therefore they at the same time used precious ointments, which, though agreeable and pleasant in themselves, are hurtful to this intention by reason of their heat; so that Virgil was right in speaking of the use of casia as corrupting the use of clear oil.[1]

20. Anointing with oil in winter contributes to health by excluding the cold; in summer, it helps to detain the spirits and prevent the dissolution of them, and to repel the force of the air, which is then most predatory.

21. Anointing with oil being one of the most powerful operations to advance longevity, I have thought it right to add some cautions, lest it endanger the health. These are four in number, answering to the four inconveniences which may follow thereon.

22. The first inconvenience is, that by keeping in perspirations it may engender diseases, from excrementitious humours. The remedy to be employed for this is by purges and clysters, so that a proper discharge may be obtained. For it is certain that discharge by perspiration is mostly good for the health, but bad for longevity. But moderate purgatives act upon the humours, and not as perspiration does, upon the spirits.

[1] Nec casia liquidi corrumpitur usus olivi. — *Georg.* ii. 466.

23. The second inconvenience is, that it may make the body hot and inflamed. For the spirit being shut in and prevented from perspiring is more fervent. The remedy for this is a diet mostly of a cooling nature, and medicines with cooling properties to be taken at certain times. But of these I will presently inquire in the operation upon the blood.

24. The third inconvenience is, that it may oppress the head. For all closing of the pores externally strikes back the vapours, and sends them to the head. This may be completely remedied by purgatives, especially clysters, by firmly closing the mouth of the stomach with astringents, by combing and rubbing the head, and also washing it with convenient lies to cause an exhalation, and by not neglecting good and suitable exercise to create a slight perspiration from the skin.

25. The fourth inconvenience is a more subtle evil; namely, that the spirit detained by the closing of the pores may possibly multiply itself too much; because, when it does not escape, and new spirit is being continually generated, the spirit increases too much, and may thus become more predatory on the body. But this is not exactly the case; for all spirit (which like flame is fanned by motion) by being shut up becomes languid, and therefore less active and less able to propagate itself; hotter, no doubt, as flame is, but slow in motion. But this inconvenience also may be remedied by an occasional mixture of cooling medicines, as roses and myrtle, with the oil. For all hot things are to be absolutely avoided, as was observed with regard to cinnamon.

26. It is likewise beneficial to wear next the skin

garments which have in them something unctuous or oily, and not watery, for they draw less out of the body. And in this respect woollen garments are better than linen; at least it is certain in the spirits of odours, that scented powders lose their smell much sooner in linen than in wool. Linen therefore, though pleasant to the touch and in respect of cleanness, is to be suspected for this operation.

27. The wild Irish, when they are taken ill, do nothing more than take the sheets off the beds, and wrap themselves in the blankets.

28. Some assert that they derived much benefit to their health by wearing under their shirts, and next the skin, drawers and waistcoats of scarlet flannel.

29. It should be observed also that air accustomed to the body preys upon it less than new and frequently changed air; and therefore poor people, who always live at home by their own firesides, and do not change their abodes, are generally long-lived. But for the other operations I esteem a change of air to be beneficial, especially where the spirits are not altogether sluggish; but a mean should be used that may meet both cases. And this may be done by changing our place of abode at stated times, at the four seasons of the year, to suitable localities; that so the body may neither travel too much, nor rest too long at home. And so much for operations by exclusion of the air, and avoiding its predatory action.

III.

THE OPERATION UPON THE BLOOD, AND THE HEAT, WHICH CREATES BLOOD.

The History.

1. The two subsequent operations are as it were the converse of the two preceding, and are related to them as passives to actives. For the two preceding tend to make the spirit and the air less depredatory in their actions; the two latter to make the blood and the juice of the body less liable to be preyed on. But as the blood is that which irrigates the juices and members, and prepares them, I will place the operation upon the blood first, and give three precepts concerning it; being few in number, but of great efficacy.

2. First, there is no doubt but that if the blood be brought to a cooler temper it will be the less easily dissipated. But since cold things taken through the mouth agree ill with many of the other intentions, it will be better to find some other things that are free from these inconveniences; and these are two in number.

3. The one is the use of clysters, especially in youth, not at all purgative or abstergent, but only cooling and slightly aperient. Of these the best are made from the juices of lettuce, purslane, hepatica, the greater houseleek, and the mucilage of the seed of fleawort, with some mild opening decoction, and the mixture of a little camphor. But in old age let houseleek and purslane be omitted, and the juice of borage, endive, and the like be substituted in their place. And let the clysters be retained as long as possible, that is, for an hour or more.

4. The other is, the use, especially in summer, of fresh water baths, only just lukewarm, with no emollients at all, as mallows, dog's mercury, milk and the like; but rather with a moderate quantity of new whey and roses.

5. But the chief point and novelty of the thing that I advise is this: before bathing anoint the body with oil mixed with some thickening substance, that the cooling property may be received, the water repelled, and yet the pores of the body may not be shut too closely. For when the external cold shuts up the body strongly, it is so far from promoting coldness, that it even prevents it, and excites heat.

6. Bladders filled with decoctions and cooling juices, and applied to the abdomen, produce a similar effect. For this also is a kind of bathing, where the body of the liquor is mostly excluded, and only the cooling property received.

7. There remains the third precept, which relates not to the quality, but to the substance of the blood; to make it more firm, less easily dissipated, and less subject to the heat of the spirit.

8. There is no confidence at the present day in the use of gold-leaf or filings, or powder of pearls, gems and coral, or the like, except so far as they may satisfy the present operation. Certainly as the Arabs, Greeks, and moderns have attributed such powers to these medicines, it would seem that there must be something in what so many men have proved and observed. Laying aside therefore all fantastic notions concerning them, I fully believe, that if something could be infused in very small portions into the whole substance of blood, over which the action of the spirit and heat

should have little or no power, it would stop not only all putrefaction, but arefaction likewise, and be very effectual in prolonging life. In this however several cautions are required. First, that the particles be reduced to an extreme fineness; secondly, that such hard and solid things be free from all malignant qualities, lest when they are dispersed and concealed in the veins, they work some mischief; thirdly, that they be never taken with food, nor so as to remain long, lest they create dangerous obstructions about the mesentery; fourthly, that they be used seldom, lest they congregate and collect in the veins.

9. Let them therefore be taken on an empty stomach, in white wine mixed with a little oil of almonds, and use bodily exercise immediately after the draught.

10. For the simples which may satisfy this operation, three will be enough; namely, gold, pearls, and coral. For all metals except gold have some pernicious quality in their volatile part, neither can they be beaten out so finely as gold-leaf. And transparent and glass-like gems I dislike, as I said before, for fear of corrosion.

11. But in my opinion, the safer and more effectual means would be the use of woods in infusions and decoctions; for these have power enough in them to give firmness to the blood, yet have not the same danger of causing obstructions. But they are most to be commended because they may be taken at meals; whence they will obtain an easier entrance into the veins, and will not pass off with the refuse.

12. The woods suited for this purpose are sandal, oak, and vine; for I reject the hotter woods, and such as are at all resinous. Yet to these I may add the dry

and woody stalks of rosemary, which is a shrub as durable as many trees; and likewise the dry and woody stalks of ivy, but not in such a quantity as to create an unpleasant taste.

13. Let these woods be taken, either boiled in broths, or infused in new wine, or beer, before it has settled. If in broths (as is the case in guaiacum and the like), let them always be infused for a long time before they are boiled, that the firmer part of the wood as well as the looser may be drawn out. Ash-wood, though used for cups, I regard with suspicion. And so much for the operation upon the blood.

IV.

THE OPERATION UPON THE JUICES OF THE BODY.

The History.

1. There are two kinds of bodies, as has been observed in the inquiry concerning inanimate bodies, which are consumed with difficulty; namely, the hard and the fat; as appears in metals and stones, in oil and wax.

2. The operation therefore must tend to make the juice of the body somewhat hard; and likewise somewhat fatty and moist.

3. Hardness is caused in three ways; namely, by aliment of a firm nature, by cold condensing the skin and flesh, and by exercise fermenting and binding the juices, that they be not soft and frothy.

4. Aliment should be of a nature that is least easily dissipated; as beef, pork, venison, goat, kid, swan, goose, and wood-pigeon, (especially if the flesh be

slightly salted), salt and dried fish, cheese rather old, and the like.

5. Bread made of oatmeal, or with a mixture of peas in it, or rye or barley bread, is more solid than wheaten bread. And in wheaten bread that which has more of the bran in it is more solid than that made of fine flour.

6. The inhabitants of the Orkneys, who live on salt fish, and fish-eaters in general, are long-lived.

7. Monks and hermits who lived sparingly and on dry food were generally long-lived.

8. Pure water likewise, drunk often, makes the juices of the body less frothy. But by reason of the dullness of the spirit (which in water is certainly not very penetrating), the mixture of a little nitre with the water would I think be useful. And so much for the firmness of aliment.

9. With regard to the condensation of the skin and flesh by cold, persons living in the open air are generally more long-lived than those living in the house; and the inhabitants of cold countries than those of warm.

10. Too much clothing either in bed or on the back relaxes the body.

11. Washing in cold water is good for longevity; the use of warm baths bad; of bathing in astringent mineral waters I have spoken before.

12. With regard to exercise, an inactive life manifestly renders the flesh soft, and easily dissipated; whereas strong exercise, without too great perspiration or fatigue, renders it hard and compact. Exercise also in cold water, as swimming, is very good, and as a general rule, exercise in the open air is better than under cover.

13. Of frictions (which are a kind of exercise), seeing they rather call forth the aliment than harden, I will speak afterwards in their proper place.

14. Now therefore having spoken of the hardness of the juices, I come to their oiliness or moistness, which is a more perfect and powerful intention than induration, seeing it has no inconvenience, nor injurious effect. For all things which relate to the hardness of the juices are of such a nature that while they prevent the waste of aliment they also hinder the repair thereof; whence the same things are at the same time favourable and hurtful to longevity. But things which pertain to make the juices roscid are advantageous in both ways; for they render the aliment at once less easy to be dissipated, and more easy to be repaired.

15. But when it is said that the juice of the body should be made fat and roscid, it must not be understood to mean an obesity or visible fat; but a dewiness diffused, or (if you will) radical, in the very substance of the body.

16. Again, let no one imagine that oil, or the fat of meats or marrow, engender things like themselves, and satisfy this intention; for things once made perfect do not return to the same state. But the nourishment should be such, as after digestion and maturation to generate an oiliness in the juices.

17. Again, let no one imagine that a mass of oil or fat by itself is difficult to dissipate, but that in a mixture with other things it does not retain the same nature. For as oil by itself is much longer in wasting than water, so likewise it adheres much longer, and dries much slower on paper or linen; as I observed before.

18. For making the juices roscid, roast or baked meats are better than boiled. All preparations of meat with water are bad; besides, oil is extracted more abundantly from dry bodies than from moist.

19. In general, a large use of sweet things is good for this operation on the body; as sugar, honey, sweet almonds, pine-apples, pistachio nuts, dates, raisins, currants, figs, and the like. And on the contrary, all acid and very salt or acrid things are opposed to it.

20. Nor let me be thought to favour the Manichæans and their diet, if I recommend a frequent use of seeds, nuts, and roots, in meats or their preparations; since all bread, which is the firmament of all food, is made either of seeds or roots.

21. But above all things, this operation depends most on the nature of the drink, which is the vehicle of food. Let therefore the drinks in use be subtle, yet free from all acrimony and acidity; as are those wines which, as the old woman says in Plautus,[1] "are toothless with age," and beer of the same kind.

22. Mead, I imagine, would not be bad, if strong and old; but since all honey has some acidity in it (as may be seen by the corrosive water that the chemists extract from it, which can even dissolve metals), it would be better to make a similar drink with sugar, not lightly infused, but incorporated as firmly as honey in mead, and keep it for a year or six months; so that the water may lose its crudity, and the sugar may acquire subtlety.

23. Age in wine or liquor engenders subtlety in the parts of the liquor, and acrimony in the spirits; whereof the first is beneficial, the second hurtful. To avoid

[1] Plaut. Pœnulus, 569.

therefore this complication, put into the cask, before the wine has settled at all, a piece of well-boiled pork or venison, that the spirits of the wine may have something to prey upon and devour, and thereby lose their pungency.

24. In the same way, if beer were to be brewed not only of the grains of wheat, barley, oats, or peas, but should likewise have about a third part of roots or fat pulps, as potato-roots, the pith of artichokes, burdock, or any other sweet and esculent roots, I conceive it would be a drink much more conducive to longevity than beer made entirely of grain.

25. All things which have very fine parts, and yet have no acrimony or pungency, are very good in seasonings. And such a property is found to exist in some few flowers, as ivy flowers, which infused in vinegar are even pleasant to the taste; marigold flowers, which are used in broths; and betony flowers. And so much for the operation upon the juices of the body.

V.

THE OPERATION UPON THE BOWELS, TO SEND FORTH THE ALIMENT.

The History.

1. Of the things which comfort the principal viscera (which are the seats of digestion), the stomach, liver, heart, and brain, for the proper performance of their functions (whereby aliment is distributed into the parts, the spirits are diffused, and reparation of the whole body is accomplished), inquire from physicians, and their descriptions and advices.

2. Of the spleen, gall, kidneys, mesentery, entrails, and lungs I make no mention, as they are only members ministering to the principal. And though in treating of health they sometimes come under especial consideration, because they each are subject to their own diseases, which if they be not cured attack likewise the principal viscera; yet for prolongation of life, repair of the body by aliment, and retarding the atrophy of old age, if digestion and the principal viscera are in a good state, the rest will commonly work satisfactorily.

3. From the medical books which handle the comforting and preserving the four principal members, each person should select for himself the diet and system suited to his own bodily state. For preservation of health generally requires temporary medicines; but length of life is to be looked for from a proper diet, and a regular order of nutrient medicines. I will here however set down a few of them, selecting the best.

4. The stomach (which is the master of the house, as they say, upon whose strength all the other digestions depend) should be so fortified and strengthened as to be moderately warm; firm, not loose; clean, and not charged with oppressive humours; and yet (seeing it is supported by itself rather than by the veins) never absolutely empty or fasting; lastly, it should be kept in good appetite, for appetite sharpens digestion.

5. I wonder how it is that the practice of taking warm drinks, which was common among the ancients, has fallen into disuse. I knew a very eminent physician who at dinner and supper would swallow exceedingly hot soup with great avidity, and soon afterwards wish it were returned; "for," said he, "I did not want the soup, but only the warmth."

6. I conceive it very beneficial that the first draught at supper of wine, beer, or whatever drink a man uses, be taken hot.

7. Wine, in which gold has been quenched, I think good once in a meal. Not that I believe that the gold has any special virtue, but because I know that the quenching of all metals in any liquor gives it a powerful astringency. And I select gold for this purpose because, besides the astringency which I want, it leaves no other metallic impression behind.

8. In the middle of a meal I conceive sops of bread dipped in wine to be better than wine by itself; especially if the wine in which the sop is dipped contain an infusion of rosemary and citron rind, with a little sugar to make it pass slower.

9. Quinces are certainly good for strengthening the stomach; but in my opinion they would be better used in conserves, which are made of strained juice and sugar, than in their solid state, because they load the stomach too much. These conserves after dinner are best taken alone, but before dinner with vinegar.

10. The best simples for the stomach are, rosemary, elecampane, mastich, wormwood, sage, and mint.

11. I approve of taking pills of aloes, mastich, and saffron, before dinner, especially in winter. But the aloe should not only be often washed with rose-water, but also steeped for some hours in vinegar in which gum-dragon has been dissolved, and afterwards in fresh oil of sweet almonds, before it is made into pills.

12. Wine or beer, with an infusion of wormwood, a little elecampane, and yellow sandal wood, is good at times, and especially in winter.

13. In summer, a draught of white wine diluted

with strawberry water, in which a very fine powder of pearls and of the shells of crawfish, and (what may seem odd) a little chalk, have been infused, refreshes and strengthens the stomach exceedingly.

14. In general, all morning draughts, (such as are commonly used,) of cooling things, as juices, decoctions, whey, barley-water, and the like, are to be avoided; and nothing which is purely cold should be taken on an empty stomach. Such things, if necessary, are better taken five hours after dinner, or one hour after a light breakfast.

15. Frequent fasting is bad for longevity. All thirst should likewise be avoided; and the stomach should be kept clean, but always moist.

16. Fresh and good olive oil, in which some mithridate has been dissolved, rubbed on the spine opposite the mouth of the stomach, comforts the stomach wonderfully.

17. A small bag of scarlet wool, steeped in rough wine, in which myrtle, citron rind, and a little saffron have been infused, may be always worn on the stomach. So much therefore for the things which comfort the stomach; whereto many of the things useful in other operations are likewise beneficial.

18. The liver only requires to be kept free from heat, or dryness, and from obstruction; for that dissolution of it, which generates watery humours, is a regular disease. But the other two are induced by age.

19. The things described in the operation upon the blood are likewise of the greatest use here; but I will select and add a few more.

20. Let wine of sweet pomegranates, or if that can-

not be had, a fresh extraction of their juice, be taken in the morning, with some sugar, a little fresh citron peel being put into the glass into which the juice has been squeezed, and three or four whole cloves; and let this be continued from February to the end of April.

21. Let watercresses be used in preference to all other herbs; but young, not old; and let them be taken either fresh, or in soups, or in drinks; and next to them scurvy grass.

22. Aloes, however washed and corrected, are bad for the liver, and therefore should never be taken ordinarily. Rhubarb on the other hand is good for the liver, if three cautions are observed; first, to take it before food, lest it be too drying, or leave some trace of astringency behind it; secondly, to steep it for an hour or two in fresh oil of almonds, with rose-water, before it is infused elsewhere, or given in its substance; thirdly, to take it alternately, at one time simple, at another with tartar or a little bay-salt, lest it only carry off the lighter parts, and make the mass of humours still more stubborn.

23. I approve of wine, or a decoction of steel, being taken thrice or four times a year, to clear away the more powerful obstructions; provided however that it be always preceded by two or three spoonsful of fresh oil of sweet almonds, and be followed by motion of the body, especially of the arms and stomach.

24. Liquids sweetened, and that with some fatness, are of special service to prevent the arefaction, saltness, parching, in short the old age of the liver; especially if they be well incorporated with age. Let such be made of fruits and sweet roots; as wine and drinks

of raisins, jujubes, dried figs, dates, parsnips, bulbous roots, potatoes, and the like, with sometimes a mixture of liquorice. A drink also made from Indian corn (which they call maize) with a mixture of sweet things is very beneficial. It is to be observed however that this intention of preserving the liver in a certain soft and fat state is much more powerful than the other, which only relates to the opening of it, and tends rather to health than length of life; except that the obstruction that parches the liver is as prejudicial as the other kinds of arefaction.

25. Roots of chicory, spinage, and beet, stripped of their pith and boiled in water till they are tender, with a third part of white wine, and used as common salads with oil and vinegar, are to be recommended; as also are the buds or stalks of asparagus, the pulps of artichokes, burdock-roots properly boiled and prepared; and in spring time broths made of the young leaves of the vine and green blades of wheat. So much therefore for strengthening the liver.

26. The heart receives the most benefit or injury from the air we breathe, from vapours, and from the passions. And many of the observations made before concerning the spirits may be transferred hither. The undigested mass of cordials which have been collected by physicians is of little use to my intention; but antidotes to poisons may be applied with sound judgment to strengthen and fortify the heart, especially if they are of a kind which does not so much destroy the peculiar nature of the poison as enable the heart and spirits to resist poison in general. With respect to cordials consult the table drawn up before.

27. The goodness of the air in places is better dis-

tinguished by experience than by signs. I consider it to be best in plains that are thoroughly exposed to the wind; if the soil is dry, and yet not altogether parched or sandy, and grows wild thyme, a kind of marjoram, and some scattered plants of calamint; and is not entirely treeless, but interspersed with some groups here and there for shade; and where the sweet-briar has a musk and aromatic smell. Rivers I consider injurious, unless very small, clear and gravelly.

28. The morning air is certainly more invigorating, though the evening is preferred for enjoyment and delicacy.

29. Air stirred by a gentle wind is I consider healthier than a calm. The best is a wind from the west in the morning, and from the north in the afternoon.

30. Odours are very good to comfort the heart; not however that a good smell is the privilege of a good air. For as some airs are very pestilential, which do not smell so ill as others that are less pernicious, so on the other hand there are airs most healthy and favourable to the spirits which have either no smell or one not so pleasant and fragrant to the sense. In general, where the air is good, scents should only be used occasionally; for a continual odour, though of the best kind, somewhat oppresses the spirits.

31. Of all odours I recommend (as I have intimated before) those of plants growing and not gathered, and taken in the open air; such as those of violets, pinks, and gilly-flowers, bean-blossoms, lime-flowers, the dust or flowers of vines, clary, the yellow wallflower, musk roses (for other roses when growing give out little smell), strawberry plants, especially when dying,

sweet-briar, especially in early spring, wild mint, and lavender flowers; and in hot countries, oranges, citrons, myrtle, and laurel. We ought therefore to walk or sit among the breaths of these plants.

32. To comfort the heart cooling odours are better than hot. The best fumigation therefore in the morning or the noon-day heats is by throwing an equal proportion of vinegar, rose-water, and strong wine on a hot iron plate.

33. Nor let me be thought to be sacrificing to Mother Earth, if I recommend in digging or ploughing to pour a quantity of generous wine upon the soil.

34. Pure orange-flower water, with a slight infusion of rose-water and fragrant wine, inhaled through the nostrils or inserted by a syringe, like an errhine, is good, if not done too often.

35. Mastication (though we have no betel) and holding in the mouth such things as cheer the spirits is very useful, though it be done continually. Make therefore grains or little cakes of ambergris, musk, lign-aloes, lignum rhodium, orrice root, and roses; and let them be made up with rose-water which has passed through a little Indian balsam.

36. The vapours arising from things taken internally to fortify and cherish the heart ought to have three properties. They ought to be friendly, clear, and cooling. Warmth in vapours is bad; and wine itself which is supposed to have only a heating vapour is not entirely devoid of an opiate property. Those vapours I call clear which have more vapour than exhalation, and are not at all smoky, sooty, or oily, but moist and uniform.

37. Among that useless collection of cordials there

are a few which should be used for diet; above all ambergris, saffron, and the grain of hermes, of the hotter kinds; and of the colder kinds, the roots of bugloss and borage, citrons, sweet lemons, and apples. Gold also and pearls, used in the way I have mentioned, may do some good, not only in the veins, but also in their passage, and in the region of the heart; namely, by cooling, without having any noxious property.

38. I am not entirely without faith in the virtue of the bezoar stone, for there have been many trials of it; yet it should by all means be taken in such a way as to communicate its virtue most easily to the spirits. It should not therefore be used in soups, syrups, rose-water, nor the like, but only in wine, cinnamon-water, or distilled liquor of that kind, and that not hot or strong, but weak.

39. Concerning the affections we have already inquired. I will only add this one remark, that every great, constant, and as they say, heroic desire, strengthens and enlarges the powers of the heart. And so much concerning the heart.

40. With regard to the brain, where the court and university of the animal spirits is held, the former inquiries concerning opium, nitre, and their subordinates, and the means for inducing quiet sleep, have some relation thereto. It is certain also that the brain is as it were under the protection of the stomach, and therefore the things which comfort and fortify the stomach by consent assist the brain, and may be transferred to this place. I will add a few remedies, three external, and one internal.

41. I recommend bathing the feet at least once a

week in a bath made of lye, bay salt, sage, camomile, fennel, sweet marjoram, spikenard, and the leaves of green angelica.

42. I recommend a fumigation every morning of dried rosemary, dry bay twigs, and lign-aloes; for sweet gums oppress the head.

43. There must be great care not to apply hot things to the head externally; such as all kinds of spices, not even excepting the nutmeg. For these hot things we would bring down to the soles of the feet, and there alone apply them. A light anointing of the head however with oil, roses, and myrtle, with a little salt and saffron, I approve.

44. Remembering what I have said before concerning opiates, nitre, and the like, which so powerfully condense the spirits, I do not think it would be amiss if once a fortnight three or four grains of castor be taken in a morning broth, with a little angelica seed and calamus aromaticus. For these both strengthen the brain, and excite in that density of the substance of the spirits (which is so necessary for longevity) vivacity and vigour of motion.

45. With respect to the comforters of the principal viscera, I have proposed those things which are both proper and choice, and which may be safely and conveniently transferred to a diet and system of life. For variety of medicines is the child of ignorance; and if it be true according to the proverb, that "many dishes have made many diseases," it is not less true that many medicines have made few cures. And so much for the operation to send forth the aliment from the principal viscera.

VI.

THE OPERATION UPON THE EXTERIOR PARTS, FOR THE ATTRACTION OF ALIMENT.

The History.

1. Although a good digestion performed by the internal parts is the principal thing for perfect alimentation, yet the actions of the exterior parts should also concur. And as the internal faculty sends forth and extrudes the nourishment, so outward faculties should attract and seize it. The weaker also the digestive faculty is, the more need is there of the aid and concurrence of this faculty of attraction.

2. A strong attraction of the outward parts is principally excited by motion of the body, whereby the parts, being warmed and comforted, invite and attract the nourishment more briskly.

3. The greatest care must be taken however that the same heat and motion, which call forth the new juice to the members, do not at the same time exhaust the member too much of that juice with which it was before moistened.

4. Frictions, especially in the morning, are most useful to this intention; but let this friction be always followed by a light anointing of oil, lest the rubbing of the outward parts should make them, by perspiration, effete and exhausted.

5. Exercise, by which the parts rub and chafe themselves, is the next best thing to friction, provided it be moderate and (as has been said before) neither rapid, nor to the utmost strength, nor to lassitude. But in this, as well as in friction, there is the same reason and

caution, that the body do not perspire too much. Wherefore exercise is better in the open air than under cover; and better in winter than in summer. Again, unction is not only to be employed when exercise is over, as in friction, but in the more violent exercises it is likewise to be used both at the beginning and at the end, as athletes do.

6. In order that exercise may dissolve as little as possible either the spirits or the juices, it should not be taken on an absolutely empty stomach. Wherefore, as exercise may neither be taken on a full stomach, as being very injurious to health, nor on an empty one, as being no less injurious to longevity, the morning repast should consist not of medicines, or draughts, or raisins, or figs, or the like, but simply of meat and drink, though in a very light and moderate quantity.

7. Exercises to distribute the juices over the body should affect all the members equally; not (as Socrates says) that the legs should move and the arms rest,[1] nor the contrary; but that all the parts should share in the motion. It is of great use also for longevity that the body should never remain long in the same posture, but should change it every half hour at least, except during sleep.

8. Things used for mortification may be transferred to vivification; for hair-shirts and flagellations, and all irritation of the outward parts, strengthen their attractive power.

9. Cardan recommends the application of nettles even in cases of melancholy; but I have no experience of the efficacy thereof, and I have some suspicions that the poisonous qualities of the nettles would

[1] Xen. Symp. ii. 17.

by frequent applications create itches and other diseases of the skin. And so much for the attraction of aliment to the exterior parts.

VII.

THE OPERATION UPON THE ALIMENT, FOR THE INSINUATION THEREOF.

The History.

1. The saying which forbids many dishes is for a censor rather than a physician. Or however it may be good for the preservation of health, yet it is prejudicial to longevity, because the various and somewhat heterogeneous mixture of aliments finds a better and quicker passage into the veins and juices than a simple and homogeneous diet does. Besides, it has great power to excite the appetite, which is the spur of the digestion. I approve therefore of a variety and frequent change of food suited to the seasons of the year, or other circumstances.

2. The doctrine likewise that meats should be simple, without sauces, is a simplicity of judgment; since good and well-chosen sauces are the most healthy preparations of food, and contribute both to health and longevity.

3. With meats hard of digestion, strong liquors and sauces that penetrate and pierce should be used; with light food, on the other hand, thin liquors and fat sauces.

4. Besides my former advice to take the first draught at supper warm, I recommend every one likewise, as a preparation for the stomach, to take half an hour before meals a good draught of whatever drink he is

accustomed to, hot, and a little spiced to gratify the taste.

5. The preparation of meats, bread, and drinks, if it be well ordered and agreeable to this intention, is of very great importance. And although it be a thing mechanical and savouring of the kitchen and the cellar, yet it is worth more than the fables of gold, precious stones, and the like.

6. The moistening of the juices of the body by a moist preparation of aliment is a childish affair; it may be of use in the heat of illnesses, but is directly opposed to roscid alimentation. Boiled food therefore, for this intention, is far inferior to roast or baked, or the like.

7. Meat should be roasted before a quick fire, and done quickly; not before a slow fire and done slowly.

8. All solid meats should be used not entirely fresh, but somewhat salted. And simple salt should be taken sparingly, or not at all, at meals; for salt distributes itself much better when incorporated in the meat than when taken by itself.

9. Various and good modes of steeping and infusing flesh in proper liquors before roasting should be brought into use; as similar methods are sometimes employed before baking, and in the pickling of some fish.

10. The beating and striking of meat before it is dressed produces a great effect. It is acknowledged that pheasants and partridges killed in hawking, and bucks and stags that have been hunted (unless the course has been too long) are of better flavour. Some fish likewise are better for being scourged and beaten. Hard and rough pears and some other kinds of fruit become sweeter by squeezing and pressing them. It would be good also to introduce a custom of beating

and bruising the harder kinds of flesh before they are put to the fire. And this will be one of the best preparations.

11. Bread a little leavened and very little salted is the best. It should be baked in an oven well heated and not too slow.

12. The preparation of drinks suited to longevity may be comprised in one precept. Of water-drinkers there is no need to speak; for, as has been said elsewhere, such a diet may continue life for a certain time, but can never prolong it to any great extent. But in other spirituous liquors (as wine, beer, mead, and the like) the one thing to be aimed at and observed as the sum of all is to make the parts of the liquor as fine and the spirit as mild as possible. And it will be difficult to effect this by age alone; for that makes indeed the parts somewhat more fine, but renders the spirits much stronger and sharper; and therefore I have already advised the infusion of some fat substance in casks, to restrain the acrimony of the spirits. There is also another way, without infusion or mixture; which is, to keep the liquor in perpetual agitation, either by water or land carriage, or by hanging the vessels on ropes and shaking them daily, or other similar processes. For it is certain that such local motion refines the parts, and in the mean time so ferments the spirits in them that they have no leisure to turn to acidity, which is a kind of putrefaction.

13. In extreme old age, food ought to be so prepared as to be almost half way to chyle. Distillations of meat are mere folly; for the best or nutritive part does not rise in vapours.

14. The incorporation of meat and drink before they

meet in the stomach is a step towards chyle. Take chickens therefore, partridges, pheasants, and the like; boil them in water with a little salt; let them be then cleaned and dried, and afterwards infused in new wine or beer that is still working, with a little sugar.

15. Extracts of meats and minces well seasoned are good for old men; the more so, because they have mostly lost the use of their teeth for chewing, which is a principal preparation.

16. Towards the supply of that defect, namely, of teeth for grinding food, there are three things which may help. The first is, to grow new ones, which is extremely difficult, and cannot be done without a radical and powerful restoration of the body. The second is, so to harden the gums by the use of proper astringents that they may in some way perform the office of the teeth; and this does not appear impracticable. The third is, to prepare the food in such a way that it does not require mastication; and this is easy, and quickly attained.

17. With regard to the quantity of meat and drink, it occurs to me that a little excess is sometimes good for the irrigation of the body; whence immoderate feasting and deep potations are not to be entirely forbidden. And so much for the operation on aliments and the preparation thereof.

VIII.

THE OPERATION UPON THE LAST ACT OF ASSIMILATION.

Transition.

The advice concerning the last act of assimilation, whereat the three preceding operations principally

aim, shall be short and simple; for the matter rather requires explanation than any variety of rules.

Comment.

1. It is certain that all bodies are endued with some desire of assimilating the things which lie next to them. This is performed freely and vigorously by thin and pneumatic bodies, such as flame, spirit, and air; but very languidly by thick and tangible bodies; because in them the desire of assimilation is controlled by a stronger desire for rest, and an aversion to motion.

2. It is certain likewise that this desire for assimilation, which in a gross body is bound up, as was said, and rendered ineffectual, is somewhat liberated and excited by heat or spirit in its neighbour, and in the end actuated by it. And this is the only reason why inanimate bodies do not assimilate, and animate bodies do.

3. Again, it is certain that the harder the consistency of a body, the greater is the heat required as a spur to assimilation. And this turns out ill for old men, because in them the parts are more stubborn and the heat is weaker; and therefore either the hardness of the parts must be softened, or the heat must be increased. With regard to the softening of the parts, as I have already laid down many precepts which relate to the prevention or prohibition of this kind of hardness, I will speak of it hereafter. But, on increasing the simple heat, I will now give one precept; first however assuming this axiom.

4. The act of assimilation (which, as has been said, is excited by the surrounding heat) is an extremely accurate and subtle motion which affects even the smallest particles. But all motions of this kind are

only in vigour when all the local motion which may disturb it is at rest. For the motion of separation into homogeneous parts, which in milk causes the cream to rise to the top and the whey to sink to the bottom, will never take place if the milk be at all stirred. Neither will any putrefaction take place in water or mixed bodies if they be in continuous local motion. From this assumption then I will draw, with reference to the present inquiry, this conclusion.

5. The act of assimilation is performed principally during sleep and rest, especially towards the morning, when the distribution is finished. The only advice therefore which occurs to me, is that men keep themselves warm during sleep, and towards morning use some ointment or anointed shirt to excite a moderate heat; and after that fall asleep again. And so much for the inquiry concerning the last act of assimilation.

IX.

THE OPERATION UPON THE INTENERATION OF THE PARTS WHICH HAVE BECOME DRY, OR THE SOFTENING OF THE BODY.

Transition.

Having already inquired of the internal inteneration of the body, which is performed by many tortuous and circuitous methods both of alimentation and detention of the spirit, and therefore by slow degrees; I now come to the inteneration which takes place from without and at once, or the softening of the body.

The History.

1. In the fable of the restoration of Pelias to youth,

Medea, when she pretended to set to work, proposed to accomplish it by cutting the body of the old man to pieces and boiling it up in a cauldron with certain drugs. Some boiling may perhaps be required there, but the cutting to pieces is unnecessary.

2. But yet the cutting to pieces (not indeed with a knife, but with the judgment) may in some sort be useful. For since the consistency of the bowels and the parts is very different, their inteneration cannot be performed by the same means; but there must be a distinct cure for each part, besides the things which pertain to the inteneration of the whole mass of the body. Of this last however I will discourse first.

3. This operation (if it be possible) may probably be satisfied by baths, anointings, and the like; with respect to which the following observations are to be noted.

4. We must not be too sanguine of accomplishing this object, because we see things done in the infusing and steeping of inanimate bodies whereby they become tender; whereof I have brought forward some instances before. For this kind of operation is easier upon inanimate bodies, because they attract and suck in the liquors; but upon animate bodies it is more difficult, because in them the motion proceeds more towards the circumference.

5. The emollient baths therefore that are in use do more harm than good; for they rather draw out than press in, and rather loosen than consolidate the framework of the body.

6. The baths and anointings suitable to the present operation of softening the body well and perfectly ought to have three properties.

7. The first and the principal one is, that they should consist of things which in their whole substance are like the flesh and body of man, and which at the same time feed and nourish from without.

8. The second is, that they be mixed with things of subtlety enough to make an entrance, and to insinuate and convey their nutritive power into the body.

9. The third is, that they receive some mixture (though far inferior to the former) with things that are astringent, not harsh or tart, but unctuous and comforting; that thus, while the two former are at work, the exhalation from the body, which destroys the virtue of the emollients, may be as far as possible stopped; and the motion to the inward parts on the other hand may, by the astriction of the skin and closing of the pores, be promoted and assisted.

10. Warm blood, either of man or animals, is most akin to the substance of the human body. But the conceit of Ficinus[1] to renew the strength of old men by sucking the blood out of the arm of a healthy young man is very foolish. For that which nourishes from within ought not to be equal or perfectly homogeneous to the body nourished, but in some degree inferior and subordinate, that it may be converted; but in external applications the more similar the substance the better the consent.

11. It is an old tradition that a bath made of infant's blood cures the leprosy, and restores the putrid flesh; and some kings have incurred popular dislike on this very ground.[2]

12. It is told of Heraclitus that, being afflicted with

[1] De Vit. Prod. ii. 11. [2] Nicephor. vii. 33. Pliny, xxvi. 5.

the dropsy, he covered himself up in the warm belly of a newly slain ox.

13. The warm blood of kittens is used for erysipelas, and to restore the flesh and skin.

14. In amputations or great hemorrhages of any limb it is good to thrust the bleeding part into the belly of an animal which has been just cut up. For this has a great effect in stanching the blood; as the blood of the amputated member by consent sucks and forcibly draws to itself the fresh blood of the animal, whereby it is itself stopped and turned back.

15. It is a common practice in extreme and desperate diseases to cut pigeons in two, and apply them one after another to the soles of the feet of the sick man. This sometimes gives wonderful relief, which is commonly imputed to their extracting the malignity of the disease. But in some way or other this treatment affects the head and comforts the animal spirits.

16. But since these bloody baths and anointings appear to us dirty and loathsome, we must look out for others which may be less disgusting and yet equally useful.

17. Next therefore to fresh blood, the things like in substance to the human body are nutritives; namely, fat flesh, as beef, pork, and venison; oysters, milk, butter, yolks of eggs, fine wheat meal, wine sweetened with sugar or honey.

18. For mixtures to make impression, salts, especially bay-salt, will serve for all. Wine also (being full of spirit) is a useful vehicle of impression.

19. Astringents of the kind described, namely, unctuous and comforting, are saffron, mastich, myrrh, and myrtle-berry.

20. Of these, as far as I can judge, such a bath as

we require may be successfully made. Physicians and posterity will discover better components.

21. The operation will become far more powerful if the proposed bath (which I hold to be the principal thing) be attended by a course and order of four operations.

22. First, before bathing, rub the body and anoint it with oil mixed with some thickening substance, that the power and moistening heat of the bath, rather than the watery part, may enter the body. Next, get into the bath, and remain there about two hours. After the bath cover the body with a plaster of mastich, myrrh, gum-dragon, diapalma, and saffron, to keep in the perspiration as much as possible, till the soft matter has by degrees become solid, and keep it on for twenty-four hours or more. Lastly, after taking off the plaster, anoint the body with a mixture of oil, saffron, and salt. Renew the bath with the plaster and unction as before every fifth day, and let the process of softening the body continue for a month.

23. While this softening process is going on, I hold it to be useful, proper, and agreeable to this intention, to nourish the body well, to keep it from cold air, and to drink nothing that is not warm.

24. But this is one of the things (as I gave notice at first) which I have not proved by trial, but only set down with a view to the end aimed at. For having set up the goal I hand on the lamp to others.

25. Warm and cherishing applications from living bodies are not to be neglected. Ficinus[1] says, and that not in joke, that the laying of the young maid in David's bosom would have done him good, but that

[1] De Vita Prod. ii. 8.

it came too late. He ought however to have added that the maid, like the Persian virgins, should have been anointed with myrrh and the like, not for the pleasure of it, but to increase the cherishing virtue from the living body.

26. Barbarossa in his last days, by the advice of a Jewish physician, continually applied young boys to his stomach, to warm and cherish it. Some old men likewise apply puppies, which are animals of the hottest kind, to their stomachs at night.

27. There is an account tolerably certain, and with the authority of many names, that some men with deformed noses, tired of being laughed at, have cut off the excrescences and shoots, and having made an incision in their arms sewed them up therein for a time, and thence obtained more comely noses. If this is true it plainly shows the consent of flesh to flesh, especially in live flesh.

28. With regard to the particular inteneration of the principal viscera, namely, the stomach, lungs, liver, heart, brain, spinal marrow, reins, gall, entrails, veins, arteries, nerves, cartilages, and bones, it would take too long to inquire and give rules concerning them, seeing I am not now prescribing a course of practice, but only certain indications thereto.

X.

THE OPERATION TO PURGE AWAY THE OLD JUICE AND TO SUPPLY NEW, OR PERIODICAL RENOVATION.

The History.

Although the things I shall here set down have been mostly touched on before, yet seeing that this is one of

the principal operations, I will handle them again a little more fully.

1. It is certain that worn out draught oxen being turned into new and fresh pastures recover young and tender flesh. This is proved by the eating; and therefore it is evident that inteneration of the flesh is not difficult; and it is probable also that this inteneration of the flesh, if often repeated, will likewise reach the bones, membranes, and the like.

2. It is certain that the diets now in use, especially of guaiacum, sarsaparilla, China-root and sassafras, if continued for a long time, and according to strict rules, first attenuate all the juice of the body, and then consume and absorb it. And this is shown very clearly in venereal diseases, which when they have even got so far as to produce gummosities, and have devoured and corrupted the inner juices of the body, may still be cured by these diets. Again, it is equally manifest that men who have grown thin, pale, and cadaverous by these diets, soon after gain fatness and colour, and are evidently renewed. Wherefore in old age, diets of this kind, used every two years, would I think be useful to my intention, like the casting of the skin in serpents.

3. Let me not be accounted one of the heretics called *Cathari*, if I affirm confidently that purgings often repeated, and made familiar to the body, do more to lengthen life than exercises and perspirations. But this must needs be so, if my previous position be admitted, that anointings of the body, filling up the pores externally, exclusions of the air, and detentions of the spirit in the mass of the body, contribute greatly to

longevity. For it is most certain that by outward sweats and perspirations, not only the humours and excrementitious vapours are exhaled and consumed, but with them also the juices and good spirits, which are not so easily restored; but this is not the case in purgings (unless they be very violent), since they act principally upon the humours. The best purgings for this intention are those which are taken a little before meals, because they dry the body less; and therefore they should consist of such purgatives as least disorder the stomach.

The intentions of these proposed operations are, I think, most true; and the remedies faithful to the intentions. And although many of them may appear very common, yet it would be scarce believed with how much care and choice they have been examined; that they might be (the object of the intention always secured) both safe and effectual. Experience however will both prove and advance this matter. But such in all things are the works of the more prudent kind of counsel; admirable in effect, excellent in order, common-place in the means employed.

THE PORCHES OF DEATH.

In connection with the 15th Article of Inquiry.

Transition.

I now come to the inquiry concerning the porches of death; that is, of the things which happen to men both a little before and a little after the point of death; that seeing that there are many paths which lead to death, we may know what are the common issues of them all, especially in deaths caused rather by a destitution of nature than by

violence; though of these likewise some notice must be inserted, by reason of their connection with the subject.

The History.

1. The living spirit seems to require three things for its subsistence; namely, suitable motion, moderate coolness, and proper aliment. Flame appears to require only two of these; namely, motion and aliment; because flame is a simple and spirit a compound substance, insomuch that if it approach too near to the nature of flame it destroys itself.

2. Flame likewise, as Aristotle[1] well observed, is extinguished and overpowered by a greater and more powerful flame; much more the spirit.

3. Flame, if it be too much compressed, is extinguished; as may be seen by putting a glass over a candle; for the air expanded by the heat compresses the flame, and thereby lessens and extinguishes it. Neither will the flame catch in grates where the fuel is pressed close together without leaving any space between the parts.

4. Ignited bodies are also extinguished by compression; for if you press a burning coal hard with the tongs or with your foot the flame is immediately put out.

5. But to pass on to the spirit. Blood or phlegm entering into the ventricles of the brain causes instantaneous death, since the spirit has not space to move.

6. A violent contusion of the head likewise causes sudden death, the spirits being straitened in the ventricles of the brain.

[1] Problems iii. 22. and xxxiii. 2.

7. Opium and other strong narcotics congeal the spirit and deprive it of motion.

8. A poisonous vapour that is directly hostile to the spirits causes sudden death; as in deadly poisons which operate by what is called a specific malignity; for it strikes the spirit with such aversion that it will no longer move nor rise against so deadly an enemy.

9. Extreme drunkenness or surfeiting likewise sometimes cause sudden death, the spirit being crushed not so much by the density or malignity of the vapour (as in opium and malignant poisons) as by the quantity of it.

10. Extreme grief and fear, especially if sudden (as the news of unexpected misfortune), sometimes produce sudden death.

11. Too great an expansion as well as too close a compression of the spirits is likewise fatal.

12. Many have died from great and sudden joys.

13. Great discharges, as the flow of water in cuttings for the dropsy, and much more, great and sudden hemorrhages, are often followed by sudden death. And this takes place from the mere horror of vacuum in the body; all the parts, and the spirit among them, rushing at once to fill the empty spaces. With respect to the slower fluxes of blood, the matter is referred to the want of aliment, not to the rushing back of the spirit. And so much for the motion of the spirit when either by over-compression or over-discharge it produces death.

14. I come now to the want of coolness. Prevention of respiration causes sudden death, as in all suffocation or strangulation; yet this should not be

attributed so much to the stoppage of motion as to the stoppage of refrigeration, because air when too hot, though it be freely drawn in, is no less suffocating than if respiration were stopped; as we see in persons who have sometimes been suffocated by burning coals or charcoal, or walls newly whitewashed, in close rooms where a fire has been lighted; a kind of death which the emperor Jovinian is said to have died. The same happens likewise from the overheating of dry baths, as was practised in the death of Fausta, wife of Constantine the Great.[1]

15. The intervals at which nature repeats the act of inspiration, and desires to expel the foul air received into the lungs and to take in fresh, are very short, — scarce the third part of a minute.

16. Again, the pulsation of the arteries and the contraction and dilatation of the heart is a motion three times more rapid than respiration; so that if it were possible without hindering respiration to stop this motion of the heart, death would ensue quicker than by strangulation.

17. Use and custom have however some control over this natural action of respiration, as appears in the Delian divers and pearl-fishers, who by continual practice can hold their breath at least ten times longer than other men.

18. Some animals even among those who have lungs can hold their breath longer than others, according as they require a greater or less degree of refrigeration.

19. Fish require less refrigeration than land animals; yet they require some, and receive it through their gills. And as land animals cannot bear a too hot or

[1] Zosimus, ii. p. 10.

close air, so likewise fish are suffocated in water if it be totally and long frozen.

20. If the spirit is assaulted by another heat far stronger than its own, it is dissipated and destroyed. For if it cannot bear its own heat without receiving refrigeration, much less can it endure a strange heat that is more intense. This is visible in burning fevers, when the heat of the putrefied humours exceeds the natural heat so much as to quench or dissipate it.

21. The wont and use of sleep is likewise referred to refrigeration. For as motion attenuates and rarefies the spirit and stimulates and intensifies the heat thereof, so on the other hand sleep pacifies and subdues its motion and discursive action. For although sleep strengthens and furthers the actions of the parts and the non-vital spirits and all motion towards the circumference of the body, yet it greatly calms and lulls the proper motion of the living spirit. Now human nature requires sleep regularly once in the twenty-four hours, and that for five or six hours at least; though in this respect also there are sometimes miracles of nature; as Mæcenas is said not to have slept for a long time before his death.[1] And so much for the want of refrigeration for the preservation of the spirit.

22. With regard to the third want, namely, that of aliment, it seems to belong more to the parts than to the living spirit; for a man may easily believe that the living spirit subsists in identity, and not by succession or renovation. As for the rational soul in man, it is most certain that it is not propagated, nor subject either to repair or death. Men talk also of the nat-

[1] Pliny, vii. 52.

ural spirit of animals and even of vegetables, which differs from the other soul both in essence and in form. For from the confusion between them has sprung the doctrine of metempsychosis and innumerable conceits of heathens and heretics.

23. The human body requires renovation by aliment regularly once a day. Men in good health can scarce bear three days' fasting; but training and custom even here have no little effect. To men out of health fasting is less injurious. And as exercise demands more nourishment, so likewise sleep to a certain extent supplies it. There are some few instances of men who, by some miracle of nature, have been found to live a considerable time without meat and drink.

24. Dead bodies, if not prevented by putrefaction, last a long time without much decay; but live bodies, as has been said, cannot, unless they receive alimentation, last more than three days. This shows that this rapid consumption is the work of the living spirit, which either repairs itself, or makes it necessary for the parts to repair themselves, or both. This is borne out also by that which was noted before, namely, that animals can go somewhat longer without aliment, if they sleep. Now sleep is nothing else than the retirement of the living spirit into itself.

25. Too continuous and copious an effusion of blood, such as sometimes takes place in hemorrhoids, sometimes in vomiting of blood from the opening or rupture of the inner veins, and sometimes in wounds, causes speedy death; for the blood of the veins supplies the blood of the arteries, which again supplies the spirit.

26. A man who feeds twice a day takes no small quantity of meat and drink into his body; much more

indeed than he discharges by stool, urine, or sweat. No wonder, perhaps you will say, seeing the rest is turned into the juices and substance of the body. True; but reflect for a moment that this accession of food takes place twice a day, and yet the body is not surcharged. And similarly, though the spirit is repaired, yet it grows not immoderate in quantity.

27. It is of no use to have aliment at hand, if it be in a remote degree; but it should be of such a kind and so prepared and applied that the spirit can act upon it. The stick of a wax torch cannot continue the flame if wax be wanting, neither can men feed on herbs alone. And this it is which occasions atrophy in old age, namely, that although there be flesh and blood, yet the spirit has become so scanty and thin, and the juices and the blood are so exhausted and obstinate, that they are not equal to alimentation.

28. Let us now sum up the things required for life, according to the common and ordinary course of nature. The spirit requires room for its motion in the ventricles of the brain and the nerves perpetually; pulsation of the heart every third part of a moment; respiration every moment; food and sleep once in three days; power of alimentation after the age of about eighty years; and if any of these wants are not supplied death ensues. Therefore there appear plainly to be three porches of death; namely, destitution of the spirit, in the motion, refrigeration, and nourishment thereof.

Admonitions. 1. It would be an error to suppose that the living spirit, like flame, is perpetually generated and extinguished, and is of no sensible duration. For

even flame does this not of its own nature, but because it lives among things hostile to it, since flame within flame is durable. But the living spirit lives among things that are friendly and obsequious. Therefore, whereas flame is a momentary and air a fixed substance, the living spirit partakes of the nature of both.

2. The present inquiry, as was observed at first, does not relate to the extinction of the spirit by the destruction of the organs through disease and violence; although this also terminates in the same three porches. And so much for the form of death.

29. There are two great precursors of death, the one sent from the head, the other from the heart, namely, convulsions and extreme labour of the pulse; for that deadly hiccough is itself a kind of convulsion. But this labouring of the pulse has a remarkable quickness, because on the point of death the heart trembles so violently that contraction and dilatation are almost confounded. But together with this quickness there is a feebleness and lowness, and often a great intermission in the pulse, the motion of the heart failing, and being no longer able to recover itself stoutly and regularly.

30. The immediate signs which precede death are, great restlessness and tossing of the body, fumbling of the hands, hard clutching and grasping, teeth firmly set, a hollow voice, trembling of the lower lip, pallor of the face, a confused memory, loss of speech, cold sweats, elongation of the body, raising up the white of the eyes, alteration of the whole countenance (as the nose becoming sharp, the eyes hollow, and the cheeks sinking in), contraction and rolling of the

tongue, coldness of the extremities, in some a discharge of blood or seed, a shrill cry, thick breathing, falling of the lower jaw, and the like.

31. Death is succeeded by deprivation of all sense and motion as well of the heart and arteries as of the nerves and limbs, by inability of the body to support itself upright, by stiffness of the nerves and parts, by loss of all warmth, and soon after by putrefaction and stench.

32. Eels, serpents, and insects move a good while in all their parts after being cut in pieces; so that countrymen imagine that the different parts are trying to unite again. Birds likewise flutter for a little after their heads are cut off; and the hearts of animals beat for a long time after being torn out. Indeed, I remember to have seen the heart of a man who had his bowels torn out (the punishment with us for high treason), which on being cast according to custom into the fire, leaped up at first about a foot and a half high, and then by degrees to a less height, for the space, as I remember, of seven or eight minutes. There is likewise an old and trustworthy tradition of an ox bellowing after his bowels were torn out. But there is a more certain report of a man, who having undergone this said punishment for high treason, when his heart had been torn out and was in the hands of the executioner, was heard to utter three or four words of prayer. This I say is more credible than the story of the sacrificed ox; because the friends of such criminals usually give money to the executioner to do his office as quickly as possible, and so put them sooner out of pain; whereas in sacrifices I do not see why the priest should use any such despatch.

33. To recover persons from swoons and sudden fits (of whom many, without relief, would otherwise die), the following remedies are used; namely, giving them waters distilled from wine (which are called hot and cordial waters), bending the body forward, close stopping of the mouth and nostrils, bending and twisting the fingers, tearing out the hair of the beard or head, rubbing of the parts, especially the face and extremities, a sudden sprinkling of cold water on the face, sudden and shrill noises, holding rose-water and vinegar to the nose in fainting fits; burning feathers or cloth in hysterics; but in apoplectic fits the best thing is a heated frying-pan. A close embrace of living bodies has likewise been of service to some.

34. There have been many instances of men who have been left for dead, laid out, and carried forth to burial; nay, of some who have been actually buried; that have yet come to life again. In the case of those who have been buried, this has been ascertained, on opening the grave, from the wounded and bruised state of the head, by reason of the body striving and tossing in the coffin. The most recent and memorable instance thereof was the subtle schoolman Duns Scotus, who having been buried in the absence of his servant (who appears to have known the symptoms of these fits), was by him afterwards disinterred and found in this state. And a similar thing happened in our time to an actor buried at Cambridge. I remember to have heard of a gentleman who, being curious to know what the sensation of hanging was, hung himself by mounting on a stool and then dropping himself off, thinking of course that he would be able to regain the stool as soon as he liked; but this he was unable to do, and he

was only released by a friend who was present. On being asked what he had suffered, he said that he felt no pain, but that at first he saw round about him the appearance of fire burning, which was succeeded by an intense blackness or darkness, and then by a kind of pale blue or sea-green colour, such as is often seen also by fainting persons. A physician still alive told me that by the use of frictions and warm baths he had recovered a man who had hung himself and been suspended for half an hour, and he made no doubt of being able to restore to life any one who had been suspended for the same time, provided his neck had not been broken by the shock of the first drop.

THE DIFFERENCES BETWEEN YOUTH AND OLD AGE.

In connection with the 16th Article of the Inquiry.

1. The scale or succession of stages in the human body is this; conception, quickening in the womb, birth, nourishment at the breast, weaning, beginning to feed upon such food and drink as are given to infants, cutting the first teeth about the second year, beginning to walk, beginning to speak, putting forth the second teeth about the seventh year, puberty about the twelfth or fourteenth year, power of generation and menstrual flux, growth of hair on the legs and arms, growth of beard, increase of stature all this time, and sometimes longer, fulness and perfection of strength and activity, grey hairs and baldness, cessation of the menstrua and of the generative power, tendency to decrepitude and a three-legged animal, death. In the mean time the mind also has its periods, though they cannot be described by years; as a failing memory and the like, of which hereafter.

2. The differences between youth and old age are these: A young man's skin is even and smooth, an old man's dry and wrinkled, especially about the eyes and forehead; a young man's flesh is soft and tender, an old man's hard; youth has strength and activity, old age decay of strength and slowness of motion; youth has a strong, old age a weak digestion; a young man's bowels are soft and succulent, an old man's salt and parched; in youth the body is erect, in old age bent into a curve; a young man's limbs are firm, an old man's weak and trembling; in youth the humours are bilious and the blood hot, in old age the humours are phlegmatic and melancholy, and the blood cold; a young man's sexual passions are quick, an old man's slow; in youth the juices of the body are more roscid, in old age more crude and watery; in youth the spirit is plentiful and effervescent, in old age poor and scanty; in youth the spirit is dense and fresh, in old age eager and rare; in youth the senses are quick and entire, in old age dull and impaired; a young man's teeth are strong and perfect, an old man's weak, worn, and falling out; a young man's hair is coloured, an old man's (whatever colour it formerly was) white; youth has hair, old age baldness; in youth the pulse beats stronger and quicker, in old age weaker and slower; a young man's illnesses are more acute and curable, an old man's chronic and hard to cure; in youth wounds heal fast, in old age slowly; a young man's cheeks are fresh-coloured, an old man's pale or rubicund, and the blood thick; youth is less troubled with rheums, age more so. Neither, as far as I know, does age bring any improvement to the body unless it be sometimes in fatness. The cause whereof is obvious; namely,

that in old age the body neither perspires nor assimilates well; and fatness is nothing else than exuberance of aliment over and above that which is discharged or perfectly assimilated. Some old men likewise have an increase of appetite by reason of the acidity of the humours, though the digestion becomes worse. But all these things that I have here mentioned the physicians will idly enough refer to the diminution of the natural heat and the radical moisture, things worthless for use. This much is certain, that in the coming on of years dryness precedes coldness, and that bodies in the highest state of heat decline to dryness, and coldness follows after.

3. Next in order comes the consideration of the affections of the mind. I remember when I was a young man at Poictiers in France that I was very intimate with a young Frenchman of great wit, but somewhat talkative, who afterwards turned out a very eminent man. He used to inveigh against the manners of old men, and say that if their minds could be seen as well as their bodies, they would appear no less deformed; and further indulging his fancy, he argued that the defects of their minds had some parallel and correspondence with those of the body. To dryness of the skin he opposed impudence; to hardness of the bowels, hardness of the heart; to blear eyes, envy, and the evil eye; to sunken eyes and bowing of the body to the ground, atheism (for they no longer, he says, look up to heaven); to the trembling of the limbs, vacillation of purpose and inconstancy; to the bending and clutching of the fingers, rapacity and avarice; to the tottering of the knees, timidity; to wrinkles, cunning and crooked ways; and other parallels which do

not now occur to me. But to be serious; youth has modesty and a sense of shame, old age is somewhat hardened; a young man has kindness and mercy, an old man has become pitiless and callous; youth has a praiseworthy emulation, old age an ill-natured envy; youth is inclined to religion and devotion by reason of its fervency and inexperience of evil, in old age piety cools through the lukewarmness of charity and long intercourse with evil, together with the difficulty of believing; a young man's wishes are vehement, an old man's moderate; youth is fickle and unstable, old age more grave and constant; youth is liberal, generous, and philanthropic, old age is covetous, wise for itself, and self-seeking; youth is confident and hopeful, old age diffident and distrustful; a young man is easy and obliging, an old man churlish and peevish; youth is frank and sincere, old age cautious and reserved; youth desires great things, old age regards those that are necessary; a young man thinks well of the present, an old man prefers the past; a young man reverences his superiors, an old man finds out their faults; and there are many other distinctions which belong rather to manners than the present inquiry. Nevertheless as old men in some respects improve in their bodies, so also in their minds, unless they are quite worn out. For instance, though less ready in invention, yet they are more powerful in judgment, and prefer a safe and sound to a specious course. They increase likewise in talkativeness and ostentation; for being less fit for action they look for fruit of speech; so it was not without reason that the poets represented Tithonus as transformed into a grasshopper.

PROVISIONAL RULES.

CONCERNING THE DURATION OF LIFE AND THE FORM OF DEATH.

Rule I.

There is no consumption, unless that which is lost by one body passes into another.

EXPLANATION.

In nature there is no annihilation; and therefore the thing which is consumed either passes into the air, or is received into some adjacent body. Whence we see spiders, flies, or ants, entombed and preserved for ever in amber, a more than royal tomb, although they are tender substances and easily dissipated. But no air reaches them into which any of their parts can escape, and the substance of the amber is so heterogeneous that it takes nothing from them. There would likewise in my opinion be a similar effect if a stick, root, or the like were put into quicksilver. Wax, honey, and gum have an operation of the same kind, but only partial.

Rule II.

In every tangible body there is a spirit covered and enveloped in the grosser body; and from this spirit consumption and dissolution take their origin.

EXPLANATION.

No known body in the upper parts of the earth is without a spirit, whether it proceed by attenuation and concoction from the heat of the heavenly bodies, or

by some other way. For the cavities of tangible things do not admit of a vacuum, but are filled either with air or the proper spirit of the thing. But this spirit, whereof I am speaking, is not a virtue, nor an energy, nor an actuality, nor any such idle matter, but a body thin and invisible, and yet having place and dimension, and real. Neither again is this spirit air (no more than wine is water), but a rarefied body, akin to air, though greatly differing from it. Now the grosser parts of bodies, being of a sluggish and not very movable nature, would last for a long time, if this spirit did not disturb, agitate and undermine them, and prey upon the moisture of the body, and whatever else it can turn into fresh spirit; after which both the pre-existing and the newly formed spirit gradually escape together. This is well exhibited by the diminution of weight in bodies dried by perspiration. For it must not be supposed that whatever is emitted either was spirit, when it had weight, or was other than spirit when it had flown.

Rule III.

The emission of the spirit produces dryness; the detention and working thereof within the body, either melts, or putrefies, or vivifies.

EXPLANATION.

There are four processes of the spirit, namely arefaction, melting, putrefaction and generation of bodies. Arefaction is not properly the work of the spirit, but of the grosser parts after the emission of the spirit; for upon this they contract themselves, partly to avoid a vacuum and partly from the union of homogeneous

things together; as is shown in all things dried by age, and in the drier kinds of bodies which have passed through the fire, as bricks, charcoal, and bread. Melting is the work of the spirits alone, and that only when they are excited by heat; for then the spirits expanding themselves and yet not going forth, insinuate and spread themselves among the grosser parts, and make them soft and molten, as appears in metals and wax; for metals and other tenacious bodies are apt to restrain the spirit, and prevent it from rushing forth when excited. Putrefaction is the combined work of the spirit and the grosser parts. For the spirit (which held together and kept in order the parts of the body) having partly escaped, and partly become feeble, all things are dissolved and return to their heterogeneities, or elements; whatever spirit there was in the body is gathered to itself (whence putrefied bodies begin to have a foul odour); the oily parts are gathered to themselves (and hence putrefied bodies have a certain smoothness and unctuosity); the watery parts likewise to themselves; and the dregs to themselves (and hence the confusion in putrefied bodies). Generation or vivification is likewise the combined work of the spirit and the grosser parts, but in a very different manner. For the spirit is entirely detained, but swells and moves locally; and the grosser parts are not dissolved, but follow the motion of the spirit, which as it were inflates and thrusts them out into various figures; whence proceeds that same generation and organization. Vivification therefore always takes place in a matter tenacious and viscous, but at the same time soft and yielding, that there may be at once both a detention of the spirit, and a gentle yielding of the parts, as the spirit moulds them. And

this appears in the matter of all things, as well vegetable as animal, whether generated from putrefaction or from seed; for there is manifest in them all a matter hard to break through, but easy to yield.

Rule iv.

In all animate bodies there are two kinds of spirits; lifeless spirits, such as are in bodies inanimate, and in addition to them a living spirit.

EXPLANATION.

I have already observed that to procure long life the human body should be considered first as a body inanimate and unsupported by aliment; and secondly as a body animate and nourished; for the first consideration gives laws touching consumption, the second laws touching repair. We should know therefore that there are diffused in the substance of every part of the human body, as the flesh, bones, membranes, organs and the like, during lifetime, spirits of the same kind as those which exist in the same things, flesh, bones, membranes and the rest, when separated and dead; such likewise as remain in the corpse. But the living spirit, though it governs them and has some agreement with them, is very different from them, being integral and self-subsisting. But between the lifeless and vital spirits there are two special differences;-the one, that the lifeless spirits are not continued in themselves, but are as it were cut off and surrounded by the grosser body which intercepts them; as air is mixed up in snow or froth. But all the vital spirit is continued in itself, by certain channels through which it passes, without being totally intercepted. And this spirit likewise is

of two kinds; the one merely branched, and permeating through small thread-like channels; the other having a cell likewise, so that it is not only continued in itself, but also collected in a considerable quantity, according to the proportion of the body, in some hollow space; and in this cell is the fountain of the streamlets which diverge from thence. This cell is chiefly in the ventricles of the brain, which in the lower animals are narrow; so that the spirits seem rather to be diffused over the body than seated in cells; as may be seen in serpents, eels and flies, the different parts whereof continue to move long after they are cut in pieces. So likewise birds quiver for some time after their heads are cut off, because they have small heads, with small cells; but the nobler animals, and men most of all, have larger ventricles. The other difference between the spirits is, that the vital spirit has in it a degree of inflammation, and is like a breath compounded of flame and air, as the juices of animals contain both oil and water. But this inflammation supplies peculiar motions and faculties; for inflammable smoke even before it catches fire is hot, rare, and movable, and yet it is a different thing after it has become flame. But the inflammation of the vital spirits is gentler by many degrees than the softest flame, whether of spirit of wine or other; and besides, it is largely mixed with an aerial substance, so as to be a mysterious combination of a flammeous and aerial nature.

Rule v.

The natural actions are proper to the several parts, but they are excited and sharpened by the vital spirit.

EXPLANATION.

The actions or functions of the individual members follow the nature of the members themselves; as attraction, retention, digestion, assimilation, separation, excretion, perspiration, and even the sense itself, depend upon the properties of the several organs, as the stomach, liver, heart, spleen, gall, brain, eye, ear, and the rest. But yet none of these actions would ever be set in motion without the vigour, presence, and heat of the vital spirit; as iron could not attract iron, unless it were excited by the magnet; and an egg could not be productive, unless the substance of the hen had been actuated by the treading of the cock.

RULE VI.

The lifeless spirits are nearly of the same substance as the air; the vital spirits more akin to the substance of flame.

EXPLANATION.

The explanation of the foregoing 4th rule is also a declaration of this; but further, it is the reason why all fat and oily substances continue to exist long in their natural state; for neither does the air prey much upon them, nor have they much desire to unite with the air. But the idea that flame is lighted air is a vain conceit, seeing that flame and air are no less heterogeneous than oil and water. When therefore this rule declares that the vital spirits approach nearer to the substance of flame, it must only be understood that they do this more than the lifeless spirits, and not that they pertain more to the nature of flame than of air.

Rule vii.

The spirit has two desires; one of multiplying itself, the other of going forth and congregating with its connaturals.

EXPLANATION.

This rule is understood of the lifeless spirits. For with regard to the second desire, the vital spirit has a special abhorrence of leaving the body, seeing it has no connaturals near at hand. It may, perhaps, rush to the extremities of the body, to meet something that it loves, but, as I said before, it is loth to go forth. But the lifeless spirits, on the other hand, are possessed by both these desires. For as to the former, every spirit seated amongst the grosser parts dwells unhappily; and being in such solitude, where it finds nothing like itself, it the more strives to make and create something similar; and to increase its quantity, it works hard to multiply itself, and prey upon the volatile part of the grosser bodies. With regard to the second desire, namely, that of escaping and resolving itself into air, it is certain that all thin bodies (which are always movable) move willingly to their likes when near at hand. One drop of water moves towards another, and flame to flame; but much more does this appear in the escape of the spirit into the external air, because it is not carried to a particle like itself, but to a very world of connaturals. In the meantime, it should be noted that the going forth and escape of the spirit into the air is a double action, arising partly from the appetite of the spirit, and partly from the appetite of the air for the common air is a needy thing, and seizes every

thing with avidity, as spirits, odours, rays, sounds, and the like.

RULE. VIII.

Spirit detained, if it have no means of generating other spirit, softens likewise the grosser parts.

EXPLANATION.

Generation of new spirit does not take place except upon things which are in a degree near to spirit, as moist bodies are. If therefore the grosser parts wherein the spirit works are in a degree remote, the spirit, though it cannot convert them, yet does all it can to weaken, soften, and disperse them; so that though it cannot increase its quantity, it may nevertheless live more freely, and amidst things that are better disposed to it. But this aphorism is very useful to our end, because it tends to the inteneration of the hard and stubborn parts of the body by the detention of the spirit.

RULE IX.

The inteneration of the harder parts proceeds well when the spirit neither escapes nor generates.

EXPLANATION.

This rule solves the knot and difficulty in the operation of softening the body by the detention of the spirit. For if the spirit when detained in the body preys upon all things within, nothing is gained towards the inteneration of the parts in their substance, but they are rather wasted and corrupted. The spirits therefore besides being detained should be cooled and confined, that they be not too active.

Rule x.

The heat of the spirit, to keep the body fresh, should be robust, but not eager.

EXPLANATION.

This rule likewise relates to the solution of the above-mentioned difficulty, but it extends much further, for it describes what should be the temper of heat in the body to dispose it for longevity. And this is useful, whether the spirits are detained or not; for in any case the heat of the spirits should be such as rather to act upon the hard parts than prey upon the soft; for the former intenerates and the latter dries up. Besides, the same thing is good to perfect alimentation; for such a heat best excites the faculty of assimilation, and at the same time best prepares the matter to be assimilated. The properties of this kind of heat should be these: First, it should be slow, not sudden; secondly, it should not be very intense, but moderate; thirdly, it should be regular and not variable, that is, not alternately increasing and decreasing; fourthly, if it meets with any resistance it should not be easily stifled or depressed. This operation is very subtle, but as it is one of the most useful it should not be neglected; and in the remedies proposed to invest the spirit with a robust heat, or that which I call operative, not predatory, I have in some measure answered this purpose.

Rule xi.

The condensation of the spirits in their substance tends to longevity.

EXPLANATION.

This rule is subordinate to the preceding; for the spirit when condensed receives all the four properties of heat there mentioned. But the methods of condensation are to be found in the first of the ten operations.

RULE XII.

The spirit is more eager to escape and more predatory in large quantities than in small.

EXPLANATION.

This rule is self-evident, seeing quantity of itself regularly increases power; as may be seen in flames, that the bigger the flame the stronger it breaks out and the quicker it consumes. And therefore too great an abundance or exuberance of the spirits is very injurious to longevity; and such a supply only is needed as will suffice for the offices of life and the furnishing of proper reparation.

RULE XIII.

The spirit if equally diffused is less eager to go forth, and less predatory, than if it is distributed irregularly.

EXPLANATION.

Not only is a large quantity of spirits in proportion to the whole injurious to the duration of things, but also the same quantity if less distributed is in like manner injurious. Therefore the more the spirit is broken up and dispersed the less predatory it is; for dissolution begins wherever the spirit is most loose. And hence it is that exercise and frictions contribute much

to longevity; for agitation is the best means of breaking up and intermingling things together in their smallest particles.

Rule xiv.

An irregular and subsultory motion of the spirits does more to hasten their emission and is more predatory than a constant and equal one.

EXPLANATION.

In inanimate bodies this rule is certain, for inequality is the mother of dissolution; but in animate bodies (where repair as well as consumption is regarded, and repair proceeds by the appetite of things, which again is sharpened by variety) it holds less strictly; yet here also it may be received with this qualification, that the variety be rather an alternation than a confusion, and as it were constant in inconstancy.

Rule xv.

The spirit in a body of firm texture is detained, though against its will.

EXPLANATION.

All things abhor a solution of their continuity, but in a degree proportioned to their density and rarity. For the more rarefied bodies are, the smaller and narrower are the passages into which they suffer themselves to be compressed; and therefore water will find a way where dust will not, air where water will not, and flame and spirit where air will not. But yet there is a limit to this; for the spirit is not so possessed with a desire of emission as to suffer itself to

be too much discontinued, or to be driven into too narrow pores or passages; and therefore if the spirit be enclosed in a hard or an unctuous and tenacious body (which is not easily divided), it is completely bound, and as it were imprisoned, and gives up its desire to issue forth. And hence we see that metals and stones require a long time for their spirit to go forth, unless either the spirit be excited by fire, or the grosser parts be disunited by strong and corrosive waters. The like reason holds good of tenacious bodies, as gums, except that they are dissolved by a gentler heat. Accordingly hard juices of the body, a tight skin, and the like (which are procured by dryness of aliment, exercise, and coldness of the air) are good for longevity, because they closely confine the spirit and prevent its emission.

Rule xvi.

In oily and fat things, though they be not tenacious, the spirit is detained willingly.

EXPLANATION.

The spirit, if it be neither irritated by antipathy to the body that encloses it, nor fed by too great a similitude of that body, nor solicited or excited by an external body, makes no great effort to go out. And oily bodies are without all these properties; for they are neither so hostile to the spirit as hard bodies, nor so similar as watery bodies, nor in good agreement with the air ambient.

Rule xvii.

A rapid escape of the watery humour preserves the oily longer in its existence.

EXPLANATION.

I have already observed that the watery humours, as being of a like substance to the air, escape sooner; the oily, as having less agreement with the air, later. But since both humours are present in most bodies, it happens that the water does as it were betray the oily; for stealing off gradually it carries that off along with it. Therefore there is nothing better for the preservation of bodies than a gentle drying of them, such as may cause the watery humour to exhale without exciting the oily; for then the oily enjoys its proper nature. And this relates not to the prevention of putrefaction (though that likewise is a consequence), but to the preservation of freshness. And hence it is that gentle frictions and moderate exercises that promote perspiration rather than sweating are very conducive to longevity.

RULE XVIII.

Exclusion of the air contributes to longevity, if you guard against other inconveniences.

EXPLANATION.

I just before observed that the escape of the spirit is a double action, from the appetite of the spirit and of the air. If therefore one of these is removed there is not a little gained; and this is chiefly to be expected from anointings. Notwithstanding it is attended by various inconveniences, the remedies whereof have been noted in the second of our ten operations.

Rule xix.

Youthful spirits introduced into an old body may shortly turn back the course of nature.

EXPLANATION.

The nature of the spirits is as it were the master-wheel which turns the other wheels in the body of man; and therefore in the intention of longevity it ought to stand first. Moreover there is an easier and more expeditious way of altering the spirits than the other parts. For the operation upon the spirits is two-fold; the one by aliment, which is slow and as it were circuitous; the other (itself likewise two-fold) which is sudden, and goes at once to the spirits, — namely, by vapours or by the affections.

Rule xx.

Juices of the body somewhat hard and roscid conduce to longevity.

EXPLANATION.

The reason hereof is plain, seeing I before laid down that hard and oily or roscid bodies are dissipated with difficulty. There is however this difference (as was likewise noted in the tenth operation), that though a hard juice is less easily dissipated, yet it is at the same time less reparable. Here therefore we have a convenience, coupled with an inconvenience, so that no great matter can be achieved thereby. But a roscid juice satisfies both operations; to this therefore we should more diligently apply ourselves.

Rule xxi.

Whatever penetrates by its rarity, and yet corrodes not by its acrimony, generates roscid juices.

EXPLANATION.

This rule is more difficult to practise than to understand. For it is evident that whatever penetrates well, but yet with a sting or tooth (as all acrid and acid things do), leaves behind it wherever it passes some trace of dryness and separation, so that it indurates the juices and dislocates the parts. But contrariwise, things which penetrate from their rarity alone, as it were by stealth and insinuation, without violence, bedew and irrigate the parts in their passage. And of these not a few have been set down in the fourth and seventh operations.

Rule xxii.

Assimilation is best performed when all local motion is at rest.

EXPLANATION.

This rule has been sufficiently explained in the commentary on the eighth operation.

Rule xxiii.

Alimentation from without, at least otherwise than by the stomach, is very beneficial to longevity, if it can be effected.

EXPLANATION.

We see that all things which are performed by nutrition take long circuits, but those done by embracing like substances (as is the case in infusions) require no

long time. Therefore external alimentation would be very useful, and the more so, because in old age the digestive faculties fail; so that if there could be some auxiliary nutritions, by bathings, anointings, or even by clysters, these things conjoined might do much, which single are of less service.

Rule xxiv.

Where the digestion is weak to send forth the aliment, there the outward parts should be comforted, so as to attract it.

EXPLANATION.

This is not the same as was propounded in the preceding rule; for it is one thing to attract the external aliment inwards, and another to attract the internal aliment outwards. But they concur in this, that they both assist the weakness of the internal digestions, though by different ways.

Rule xxv.

All sudden renovation of the body is effected either by the spirits or by emollients.

EXPLANATION.

There are two things in the body, namely, spirits and parts; to both of which the way by nutrition is long; but the way to the spirits by vapours or the affections, and to the parts by emollients, is short. But it is to be carefully observed, that I do not at all confound external alimentation with mollifying; for it is not the intention of emollients to nourish the parts, but only to make them more ready to be nourished.

Rule xxvi.

Softening of the body is performed by things of a like substance, by things that insinuate themselves, and things that close the pores.

EXPLANATION.

The reason hereof is evident; for like substances properly soften, things which insinuate themselves conduct, and things which close the pores restrain, and keep in the perspiration, which is a motion opposed to softening. Therefore (as was described in the ninth operation) this softening cannot be well performed at once, but it must be by a course and order. First, by covering the body with some thick coating, so as to exclude the liquor; for an extraneous and gross infusion does not well consolidate the body, and that which enters it should be subtle and a kind of vapour. Secondly, by inteneration, through the consent of similar substances; for bodies when touched by things which agree well with them open themselves and relax their pores. Thirdly, these insinuating things are conductors, which help to convey similar substances into the body, and a mixture of gentle astringents meanwhile somewhat checks perspiration. But, fourthly, comes that great astringency or closing of the pores by a thick plaster, and afterwards in a gradual process by anointing; till the soft becomes solid, as was mentioned in its proper place.

Rule xxvii.

Frequent renovation of the reparable parts refreshes likewise those that are less reparable.

EXPLANATION.

In the introduction to this history, the way of death was said to be this, that the more reparable parts perish in the embrace of the less reparable; so that all our efforts are to be exerted to repair these less reparable parts. Admonished therefore by Aristotle's observation touching plants, namely, that putting out new branches refreshes the trunk in the passage of the juice, I conceive that there might be the same result if the flesh and blood of the human body were often renewed; that thence the bones themselves, the membranes, and other parts of a less reparable nature, might partly by the brisk passage of juices, and partly by the new covering of fresh flesh and blood, be watered and renewed.

RULE XXVIII.

Refrigeration which passes not through the stomach is useful to long life.

EXPLANATION.

The reason hereof is obvious; for as refrigeration, not temperate but powerful (especially of the blood), is very necessary to longevity, this can by no means be performed from within to the desired extent, without destroying the stomach and bowels.

RULE XXIX.

The complication arising from the fact that consumption and repair are both the works of heat, is the greatest obstacle to longevity.

EXPLANATION.

Almost all great works are destroyed by a complication of natures, that which is beneficial in one respect being hurtful in another; so that herein there is need of an accurate judgment and a discreet practice. And this I have done, as far as the matter allows and I can at present devise, by separating kindly heats from hurtful, and the things which tend to both.

RULE XXX.

The cure of diseases requires temporary medicines; but longevity is to be procured by diets.

EXPLANATION.

Things which come by accident cease as soon as the causes are removed; but the continuous course of nature, like a flowing river, requires likewise a continual rowing or sailing against the stream; therefore we must work regularly by means of diets. Diets are of two kinds; set diets, which are to be used at certain times, and the common diet for daily life. And of these the former kind, that is, courses of medicine to be used for a time, are the more potent; for things that have power enough to turn back the course of nature are mostly too strong, and produce alterations too sudden to be safely taken into common use. Now, in the remedies proposed in conformity with these intentions, you will find only three set diets; namely, an opiate diet, an emollient diet, and a diet emaciating and renewing. But amongst the things which I have prescribed for common diet and daily life the most efficacious are these, which likewise have nearly the

same force as set diets, namely, nitre and its subordinates; government of the affections, choice of pursuits; refrigerations which do not pass by the stomach; drinks that engender roscid juices; impregnation of the blood with some firmer substance, as pearls and woods; proper anointings to keep out the air and detain the spirit; applications of heat from without during the time of assimilation after sleep; caution with respect to such things as inflame the spirit and give it a predatory heat, as wines and spices; and a moderate and seasonable use of things which give a robust heat to the spirits, as saffron, cress, garlic, elecampane, and compound opiates.

Rule xxxi.

The living spirit perishes immediately, when it is deprived either of motion, or of refrigeration, or of aliment.

EXPLANATION.

These are the three things which before I called the porches of death, and they are the proper and immediate passions of the spirit. For all the organs of the principal parts serve to perform these three offices; and again all destruction of the organs which causes death brings it to this, that one or more of these fail. Therefore all the rest are but different ways to death that end in these three. But the fabric of the parts is the organ of the spirit, as the spirit is the organ of the reasonable soul, which is incorporeal and divine.

Rule xxxii.

Flame is a momentary, air a permanent substance; the living spirits of animals are of a middle nature between the two.

EXPLANATION.

This matter requires a deeper investigation and a longer explanation than pertains to the present inquiry. In the meantime it should be known that flame is being continually generated and extinguished, so that it is only continued by succession. But air is a permanent body that is not dissolved; for though new air be created out of watery moisture, yet the old air still remains; whence comes that surcharge of the air mentioned in the title concerning the Winds. But the spirit partakes of both natures, both of flame and air; as likewise its nourishers are oil, which is homogeneous to flame, and air, which is homogeneous to water. For the spirit is not nourished by the oily part alone, nor by the watery part alone, but by both together; and though air does not sort well with flame nor oil with water, yet in a mixed body they agree well enough. Likewise the spirit gets from air its easy and delicate impressions and receptions, but from flame its noble and powerful motions and activity. In like manner also the duration of the spirit is a compound thing, not so momentary as flame, nor yet so permanent as air. And it differs the more from the conditions of flame because flame itself is extinguished by accident, namely, by contraries and the hostile bodies that surround it, a condition and necessity whereto the spirit is not subject; and the spirit is repaired from the fresh and lively blood of the small arteries which are inserted into the brain, but this repair takes place according to its own manner, whereof I am not now speaking.

THE

HISTORY OF DENSE AND RARE,

OR

THE THIRD TITLE

IN

NATURAL AND EXPERIMENTAL HISTORY,

FOR THE

FOUNDATION OF PHILOSOPHY:

BEING THE THIRD PART OF THE INSTAURATIO MAGNA.

THE

HISTORY OF DENSE AND RARE,

OR

THE CONTRACTION AND EXPANSION OF MATTER IN SPACE.

INTRODUCTION.

No wonder if nature be in debt to philosophy and the sciences, seeing she has never yet been called on to render an account. For of the quantity of matter, and how it is distributed in bodies (abundantly in some, sparingly in others), no careful and methodical inquiry according to true or approximate calculations has been instituted. One axiom has been rightly received, namely, that nothing is taken from or added to the sum of the universe. And the question, How bodies may be relaxed and contracted more or less without the interposition of vacuum, has been handled by some. But with respect to the natures of Dense and Rare, one has referred them to abundance and paucity of matter; another has laughed at this idea; the majority, following their author, discuss and settle the whole matter by that frigid distinction between act and power. And even those who attribute these things to the proportions of matter (which is the true opinion), and do not maintain the first matter to be entirely deprived of quantity, though indifferent for other forms; yet

end the inquiry here, and seek nothing further, without perceiving what follows therefrom; and whereas the matter bears upon an infinity of things, and is as it were the basis of natural philosophy, they either do not touch, or at least do not press it.

In the first place therefore, that which has been well laid down must not be disturbed: namely, that in no transmutation of bodies is there any reduction either from nothing or to nothing, but that it belongs to the same omnipotence to create something out of nothing as to turn something into nothing, and that this never happens in the course of nature. Therefore the sum total of matter remains always the same, without addition or diminution; but that this sum of matter is variously distributed among different bodies cannot be doubted. For no one can be so demented by abstract subtleties as to imagine that one hogshead of water contains as much matter as ten; or that one hogshead of air contains as much as ten. That in the same body the quantity of matter is multiplied in proportion to the measure of the body no man questions, but whether it be so in different bodies is disputed. But if it be demonstrated that one hogshead of water turned into air is equal to ten hogsheads of air (I take this computation because of the common opinion, though a hundred would be nearer the truth), it is well; for now they are no longer different bodies, water and air: it is the same body of air contained in ten hogsheads. And one hogshead of air, as has been just granted, is only a tenth part of ten hogsheads.

It can no longer be denied, therefore, that one hogshead of water contains ten times as much matter as

one hogshead of air. And therefore to say that a whole hogshead of water can be turned into one hogshead of air, is as much as to say that something can be reduced to nothing; for as a tenth part of the water would be enough for this, the other nine parts must needs be annihilated. On the other hand, to say that a hogshead of air can be turned into a hogshead of water, is as much as to say that something can be created from nothing; for a hogshead of air will only make a tenth part of a hogshead of water, and therefore the other nine parts must needs be created from nothing. Meanwhile I fully admit that to calculate the proportions and quantities of matter existing in different bodies, and to find by what industry and sagacity true information thereof may be procured, is a very difficult thing; though indeed it is amply compensated by the vast and universal utility of the inquiry. For to know the densities and rarities of bodies, and much more, to procure and accomplish the condensations and rarefactions thereof, is a point of first importance both for contemplation and practice. Seeing therefore that it is a thing of all others the most fundamental and universal, we must gird ourselves up to deal with it; for indeed without it all philosophy is utterly discinct and disorderly.

The History.

A TABLE SHOWING THE CONTRACTION AND EXPANSION OF MATTER IN RESPECT OF SPACE, IN TANGIBLE BODIES (SUCH AS ARE ENDOWED WITH WEIGHT); WITH A COMPUTATION OF THE PROPORTIONS IN DIFFERENT BODIES.

The same space is occupied by a quantity of

	Dwt.	Gr.		Dwt.	Gr.	
Pure gold . weighing	20	0	Oil of vitriol	1	21	
Quicksilver . .	19	9	White sand .	1	20	
Lead . . .	12	1½	Chalk . .	1	18½	
Pure silver . .	10	21	Oil of sulphur	1	18	
Tin glass . .	10	12	Powder of common salt .	1	10	
Copper . .	9	8				
Yellow brass .	9	5				
Steel . . .	8	10	Lignum vitæ	1	10	
Common brass .	8	9	Mutton .	1	10	
Iron . . .	8	6	Aqua-fortis	1	7	
Tin . . .	7	22	Ox horn .	1	6	
Loadstone . .	5	12	Indian balsam .	1	6	
Touchstone .	3	1				
Marble . .	2	22¾	Raw calves' brains	1	5	a little less.
Flint . . .	2	22½				
Glass . . .	2	20½	Sheep's blood	1	5	
Crystal . .	2	18	Red sandal wood	1	5	
Alabaster . .	2	12				
Muriate of soda .	2	10	Jet . .	1	5	
Common clay .	2	8½	Fresh onion	1	5	
White clay . .	2	5½	Cow's milk .	1	4½	
Nitre . . .	2	5	Camphor .	1	4	
Ox bone . .	2	5	Pressed mint juice	1	4	
Powder of pearls .	2	2				
Sulphur . .	2	2	Pressed borage juice	1	3½	
Common earth .	2	1½				
White vitriol .	1	22	Strong beer of hops	1	3½	
Ivory . . .	1	21½				
Alum . . .	1	21	Ebony wood	1	3½	

	Dwt.	Gr.	
Powder of sweet fennel seed	1	3½	
Vinegar	1	3½	
Cider of sour apples	1	3	
Clear amber	1	3	
Urine	1	3	
Common water	1	3	a little less.
Chemical oil of cloves	1	3	a little less.
Claret	1	2¾	
Powder of white sugar	1	2½	
Yellow wax	1	2	
China root	1	2	
Raw winter pear	1	2	
Distilled vinegar	1	1	
Distilled rose-water	1	1	
Common ashes	1	0½	
Myrrh	1	0	
Benzoin	1	0	
Butter	1	0	
Fat	1	0	
Oil of sweet almonds	0	23½	
Pressed oil of green mace	0	23½	
Powder of sweet marjoram	0	23	
Petroleum	0	23	
Powder of rose-flowers	0	22	
Spirit of wine	0	22	
Oak wood	0	19½	
Powder of common soot from the chimney	0	17	
Fir wood	0	15	

The manner of the experiment with respect to the foregoing Table.

The weights here used are the same as those used by goldsmiths; the pound consisting of 12 ounces, the ounce of 20 pennyweights, and the pennyweight of 20 grains. And I chose pure gold as the standard to which other bodies should be referred; because gold is not only the heaviest, but likewise the most uniform and consistent substance there is; having nothing volatile about it. The experiment was this: — I formed an ounce of pure gold into the shape of a die or cube; I then prepared a small hollow prism of silver in which the cube of gold might be placed so as exactly to fit; only that the height of the prism was somewhat greater; the place inside to which the top of the cube reached being however marked with a conspicuous line. This I did for the sake of fluids and powders; that when a fluid was

poured into the prism up to that height, it might have a little margin to keep it from overflowing. At the same time I had another prism made, exactly equal to the other in weight and dimension; that the two prisms being in all respects alike, the proportions of the bodies contained therein might be exactly compared. Next I had cubes made of the same size and dimension in all the matters specified in the Table, that admit of being cut into that shape; but fluids I made trial of at once, by filling the prism with the fluid up to the line that had been marked. And I did the same with powders; first pressing them together as close as possible; for this tends to make them uniform, and excludes accidental differences. Therefore the trial was no other than this; one of the prisms was placed in one scale empty; the other with the body in it in the other; and so the weight of the body contained was taken separately. Now, by how much the weight of a body is less than the weight of gold, by so much is the bulk of that body greater than the bulk of gold. As for example, since the cube of gold weighs one ounce, and the cube of myrrh one pennyweight, it is manifest that the bulk of myrrh in proportion to the bulk of gold is as twenty to one; so that there is twenty times as much matter in gold as in an equal bulk of myrrh and again there is twenty times as much bulk in myrrh as in an equal weight of gold.

Admonitions. 1. The smallness of the vessel employed, and the shape also (though convenient for receiving these cubes), were not favourable for verifying the exact proportions. For it was not easy to take differences of weight below a quarter of a

grain; and besides, in that square surface a slight and insensible increase of height might carry with it a sensible difference in weight, which is not the case in vessels which rise to a point.

2. No doubt but many of the bodies set down in the Table admit of more and less, as to gravity and bulk, in their own species. For both wines and woods of the same species vary in weight, some being certainly heavier than others; and so do certain other of the substances enumerated. Therefore with respect to nice calculation there is some uncertainty. And moreover those individuals with which my experiment deals may not represent exactly the nature of their species, nor perhaps agree to a nicety with the experiments of others.

3. In the above Table I have included such bodies as could conveniently be made to fill up the space or measure, the body remaining entire and uniform; and such likewise as have weight; from the proportion of which I formed a judgment of the amount of matter collected. There are therefore three kinds of bodies which could not be included; first, those which will not go into the shape of a cube, as leaves, flowers, pellicles, and membranes; secondly, those which are unequally hollow and porous, as sponge, cork, and wool; and thirdly, pneumatic bodies, as air and flame, because they are not endowed with weight.

4. It should be observed whether the close contraction of a body may not, by reason of the union of force, give it a greater degree of weight than in proportion to the quantity of matter. Whether this be so or not should be inquired from the particular

history of Gravity. If it be so, the calculation no doubt fails; and the more rarefied a body is, the more matter will it contain within the same bulk than would appear from a calculation founded upon the weight as compared with the measurement. This Table I constructed many years ago, and (as I recollect) took considerable pains about it. But a much more accurate Table may no doubt be made; consisting of a greater number of bodies, measured on a larger scale; a thing that contributes greatly to exactness in the matter of proportions. And seeing that this is fundamental to the subject, such a Table should by all means be prepared.

Observations.

1. Here we may observe with satisfaction how finite and comprehensible the nature of things is in tangible bodies. For the Table brings nature as it were within the grasp. Let no one wander off therefore, or indulge in fancies and dreams. In this Table there is no substance found that exceeds any other substance in quantity of matter beyond the proportion of 32 to 1; which is the proportion in which gold exceeds fir wood. Of things in the interior of the earth however I say nothing, seeing that they are not subject either to sense or experiment. These, it may be, being both far removed and completely separated from the heat of the heavenly bodies, are more dense than any known bodies.

2. The opinion that all sublunary bodies are composed of the four elements is ill borne out. For the cube of gold in the prism weighed 20 pennyweights; the common earth only a little more than 2; water 1

pennyweight 3 grains; air and fire are far more rarefied, and less materiate, and of no weight at all. Now form does not increase matter. The question is therefore, how it is possible from a body of 2 pennyweights, together with others far more rarefied, to educe by form a body which in an equal dimension weighs 20 pennyweights. There are two ways of escaping the difficulty. It may be said, first, that the more rarefied elements press the denser into a greater density than that of the simple element; secondly, that the Peripatetics do not understand this of common but of elementary earth, which is heavier than any compound substance. But for the first, fire and air do not condense except by accident, as shall be shown in its proper place. And for the second, that earth which should be heavier than gold and everything else, is so situated as to be scarce available for mixture. It would be better therefore that they should give up trifling, and that the dictatorship should cease.

3. The series or scale of closeness in matter should be carefully observed; and how it passes from a greater to a lesser; and that sometimes by steps, sometimes by jumps. For this speculation is useful, both for judgment and practice. This closeness is greatest in metallic and subterraneous bodies; so that of the 32 parts they possess 12; such being the distance between gold and pewter. In this descent there is a great leap from gold and quicksilver to lead; but a gradual incline from lead to tin. Again, there is a great leap from metals to stones, except that the magnet intervenes, which is thereby proved to be a metallic stone. But from stones to the other bodies down to the very lightest the descent is very gradual and continuous.

Injunctions. 1. The source of density being as it seems in the depth of the earth, so that towards its surface bodies are extremely extenuated, it is worthy of remark that gold (which is the heaviest of metals) is yet sometimes found in the sands and deposits of rivers, and that nearly in a pure state. Careful inquiry should therefore be made as to the situation of such places; whether they do not lie at the foot of mountains, the roots and foundations whereof may be compared with the deepest mines, and whether gold be not washed away from thence; or what it is that produces such a condensation so near the surface of the earth.

2. There should be an inquiry touching mines in general; which kinds are usually the deeper, and which nearer the surface of the earth; in what regions and in what soils they are formed; how they are with reference to water; but most of all in what beds they lie; and with what stones or other fossils they are surrounded or mixed. In short, everything pertaining to them should be examined, to discover by what means the juices and spirits of the earth are united or compressed into that metallic condensation, which so far exceeds all others.

Observations.

4. There is no doubt but that both in vegetables and likewise in the parts of animals there are many bodies to be found far lighter than fir wood. For the down of some plants, the wings of flies, the slough of snakes, and also various artificial productions, as tender

rose-leaves remaining after distillation, and the like, are (as I conceive) lighter than the lightest woods..

5. That idea to which the human mind is prone, namely, that hard bodies are the densest, is to be checked and corrected. For quicksilver is a fluid, gold and lead are soft; yet these are denser and heavier than the hardest metals (iron and brass), and much more so than stones.

6. In the Table there are many unexpected results. For instance, that metals are so much heavier than stones; that glass (a refined body) is heavier than crystal (a congealed body); that common earth has so little weight; that the distilled oils of vitriol and sulphur are nearly as heavy as the raw substances; that there is so little difference between the weight of water and wine; that chemical oils (which would seem to be more fine and subtle) are heavier than expressed oils; that bone is so much heavier than horn and teeth; and many other things of a similar character.

Injunction. 3. The nature of Dense and Rare, though it pervades nearly all other natures without being subject to their laws, appears only to have a great agreement with Heavy and Light. But I suspect that it has likewise something in common with the slow and quick reception and rejection of heat and cold. Make experiment therefore whether rare bodies do not admit and lose heat or cold more quickly than dense ones. And try this in gold, lead, stone, wood, and the like; but do it with the same degree of heat, and with the same quantity, and figure of body.

Reminders concerning Practice.

1. All mixture of bodies may be detected and disclosed by means of the Table and Weights. For if you wish to find how much water is mixed with wine, or how much lead with gold, and the like; weigh the mixture, and then consult the Table of specific gravities. The mean proportion of the compound compared with the simples will give the quantity of the mixture. I suppose this was the εὕρηκα of Archimedes; but at any rate the thing is so.

2. The manufacture of gold, or the transmutation of metals into gold, is to be much doubted of. For of all bodies gold is the heaviest and densest, and therefore to turn anything else into gold there must needs be condensation. But condensation (especially in very materiate bodies, as metals are) can scarce be superinduced by us men who live on the surface of the earth. For most condensations by fire are *pseudo-condensations* with respect to the entire body (as will afterwards appear); that is, they condense bodies in certain of their parts, but not in the whole.

3. But the conversion of quicksilver or lead into silver (which is rarer than either of them) is a thing to be hoped for; since it only implies fixation, and some other things, but not condensation.

4. Notwithstanding if quicksilver, lead, or any other metal could be turned into gold, so far as to have all the other properties thereof except weight; that is, if they could be made more fixed, more malleable, more ductile, more durable, less subject to rust, brighter, yellower, and the like; it would

doubtless be both profitable and useful, even though they did not acquire the weight of gold.

Observation.

7. There is nothing heavier than gold; and up to this time no invention has been discovered to make pure gold heavier by art.

It has been remarked however that lead increases both in bulk and weight, especially if it be stored in cellars under ground, where things soon gather rust. This has been principally detected in stone statues, whose feet were fastened with leaden bands. For these bands have been found to swell; so that portions of them hung from the stones like warts. But whether this were an increase of the lead, or a sprouting of vitriol, should be more fully inquired.

The History.

A TABLE OF THE BULK OF MATTER WITHIN A GIVEN SPACE OR DIMENSION IN THE SAME BODIES WHOLE AND POWDERED.

	Dwt.	Gr.		Dwt.	Gr.
Mercury in body, as much as will fill the prism, weighs	19	9	Sublimate of mercury in a compressed powder weighs .	3	22
Lead in body . . .	12	1½	Ceruss, in a compressed powder .	4	8½
Steel in body . .	8	10	in powder prepared as in medicines, and compressed .	2	9
Crystal in body . .	2	18	ground and compressed	2	20
Red sandal wood in body	1	5	in a compressed powder	0	16½
Oak wood in body .	0	19½	in ashes . . .	1	2

A TABLE OF THE BULK OF MATTER WITHIN A GIVEN SPACE OR DIMENSION, IN BODIES CRUDE AND IN BODIES DISTILLED.

	Dwt.	Gr		Dwt.	Gr.
Sulphur in body .	2	2	in a chemical oil .	1	18
Vitriol in body .	1	22	in oil .	1	21
Wine in body .	1	2¼	distilled .	0	22
Vinegar in body .	1	3½	distilled .	1	1

Admonition. The manner of converting a body into powder conduces much to the opening or expansion of the body. For the process by simple rubbing or filing is one thing, that by sublimation, as in mercury, another; that by strong waters and corrosives (that is by turning the bodies into rust) as in oxide of iron, and slightly in prepared steel, another; and that by burning, as ashes and lime, another. Therefore these are by no means to be regarded as the same.

Injunction. These two Tables are extremely meagre. That would be a perfect table of bodies with their openings, which should give first the weight of every body in its whole state; secondly, that of its crude powder; thirdly, that of its ashes, calcination, and rust; fourthly, that of its amalgamations; fifthly, that of its vitrifications (if it is vitrifiable); sixthly, that of its distillations (subtracting the weight of the water wherein it is dissolved), with all the other alterations of the same body; that so a judgment might be formed of the openings of bodies, and the closest connections of integral nature.

Observations.

1. Powders are not properly openings of bodies, because the increase of space is not caused by dilatation of the body, but by interposition of air; yet an excellent estimate of the internal closeness or porosity of bodies is obtained thereby. For the closer bodies are, the greater is the difference between their powder and their body entire. Therefore the proportion of crude quicksilver to sublimate of mercury in powder is as five to one, or rather more. The proportions of steel and lead are not quite so much as four to one. But in lighter and porous bodies the position of the parts is sometimes looser in the entire body than in its powder when compressed; as in oak wood, the ashes are heavier than the body itself. So likewise in the powders themselves, the heavier a body is the less dimension has the powder when pressed, compared with the same unpressed. For in lighter bodies the parts of the powders (as they less compress and cut the air that is mixed with them) can so support themselves that the powder unpressed will fill three times as much space as when pressed.

2. Distilled bodies are generally rarefied, and lose in weight; but wine does this twice as much as vinegar.

Speculation.

1. Tangible bodies have thus been divided into classes of rich and poor. There remains still another class, namely, that of pneumatic bodies; but these are not indued with weight, the effect of which would enable us to form a judgment of the bulk of matter contained in them. We require therefore another

kind of interpreter. But first I must set forth the kinds of pneumatic bodies, and then proceed to compare them.

As in tangible bodies I postpone for a while the inquiry of the internal parts of the earth, so in pneumatic bodies I postpone speaking of things eternal.

Pneumatic bodies with us are of three kinds; imperfect, attached, and pure. The imperfect are fumes of all kinds, and arise from different matters; which may stand in this order. First, volatile fumes, that exhale from metals and some fossils, which (as their name signifies) are rather volatile than pneumatic; because they are very easily coagulated, either by sublimation or by falling or precipitation. Secondly, vaporous fumes that exhale from water and watery bodies. Thirdly, fumes (using the general name in a special sense) that exhale from dry bodies. Fourthly, exhalations from oily bodies. Fifthly, breaths from bodies watery in their substance and inflammable in their spirit; as are wines, fermented liquors, and strong drinks.

There is likewise another kind of fumes; namely, those in which flame terminates. But these can only exhale from inflammable bodies, as they succeed flame. These I call *after-fumes* or *secondary fumes*. Therefore there can be no *after-vapours*, because watery bodies are not inflammable; but there may be *after-fumes* (using the word in the special sense), *after-exhalations*, *after-breaths*, and likewise, as I conceive, in some bodies, *after-volatiles*.

Attached pneumatic bodies are those which are not found by themselves or free, but only inclosed in tangible bodies; and are the same as what are commonly

called spirits. They partake both of an oily and a watery substance, and are nourished by the same; which, on being converted into a pneumatical substance, constitute a body composed as it were of air and flame, and combining the mysterious properties of both. Now these spirits (in the case of free pneumatic bodies) approach very nearly to the nature of breaths; such as rise from wine or salt. They have two natures; the one of crude, the other of living spirits; whereof the former exist in every tangible body, the latter only in such as are animated, whether of the vegetable or sensitive world.

Of pure pneumatic bodies there are only two; namely, air and flame; though these also admit of great variety, and unequal degrees of bulk.

A TABLE OF PNEUMATIC BODIES ACCORDING TO THE FOREGOING SPECULATION, ARRANGED IN ORDER OF BULK.

The volatile parts of metals and fossils.	Breaths.
The after-volatile parts of the same.	After-breaths.
Vapours.	Crude spirits attached in tangible bodies.
Fumes.	Air.
After-fumes.	Living or kindled spirits attached in tangible bodies.
Exhalations.	Flame.
After-exhalations.	

We are now to inquire of the bulk of these bodies as compared with one another, and also with tangible bodies. And if the nature of lightness could by its tendency upwards make manifest the rarity of bodies, as the nature of heaviness by its tendency downwards makes manifest their density, the comparison might

well be made. But there are many difficulties in the way.

First, the differences of motions in invisible bodies are not immediately perceptible to the sense. Secondly, there is not found in air and similar bodies such a strong desire of mounting upwards as is generally supposed. Lastly, if the air did mount upwards, yet, as it commonly forms a continuous body with other air, the motion would be scarce perceptible. For as water does not weigh upon water, so air does not rise up through air. And therefore other means must be devised.

Now that pneumatic bodies do in fact vary in bulk, one compared with another, and that the order and series of rarity as set down in this Table rests upon solid ground, some tolerable evidence may be produced. But as to the precise degrees of bulk in different pneumatical bodies, compared with each other, and also in pneumatical bodies as compared with bodies tangible, the inquiry is certainly more difficult.

First, then, it is probable that all fumes, secondary as well as primary, are inferior in rarity to air. For they are visible, which the air is not; and they themselves, after they are mixed with the air, soon become invisible.

That after-fumes are more thin and rare than fore-fumes is sufficiently evident; for they are the carcasses and solutions of flame, which is itself so subtle a body. It is proved likewise by experience that in night entertainments, where rooms are lighted by so many lights and torches, the air is still good enough for respiration, even after the lapse of many hours, notwithstanding the quantity of after-fumes received into it; whereas

if these fumes were fore-fumes (such as those of candles and torches put out, and smoking without flame) no one could endure them even for a much shorter time.

All crude spirits attached in tangible bodies are likewise, in my opinion, denser than the air. For the spirits of vegetables, dead animals, or the like, when they have exhaled, manifestly retain something gross or tangible; as may be seen in odours; which, being nothing but fumes going out by little and little, and not in a body, as invisible fumes and vapours do, yet if they light on anything tangible, especially if it be soft, they apply themselves to it, adhere to it, and infect it with their odour. It is manifest therefore that they have an affinity with a gross nature, which is not easily thrown off.

But living spirits, I conceive, are somewhat rarer than the air itself; both because they have somewhat of the nature of flame, and also because I have found, by careful trial, that air has no power to diminish or lighten weight. For an inflated bladder, though it is filled with air, is not lighter than when it is empty and compressed; and so likewise a sponge or fleece of wool filled with air is not lighter than the same when empty, with the air excluded. But there is a manifest difference in the weight of a live and dead body, though not so great as is commonly thought. Whence it appears that air does not diminish weight, but that the living spirit does. And as weight determines densities, so diminution of weight should determine rarities.

Last in order comes flame, both because it manifestly mounts upwards, and because it is probable that the proportions of pneumatic bodies do not differ from

the proportions of the bodies that feed them; and therefore that as oil is rarer than water, so flame is rarer than air and spirit. Flame likewise appears to be a thinner, softer, and more yielding body than air; for the least breath or commotion of air near a lighted candle will make the flame tremulous.

The History.

1. With regard to the comparative expansion of pneumatical and tangible bodies, though it be a thing difficult to be discovered, yet I have not laid aside all care about its inquiry. Now it seemed to me that the most certain proof would be this: if any tangible body (whereof the bulk has been previously taken and measured) could be absolutely turned into a pneumatic body, and then the bulk of that were likewise observed. For a comparison of the proportions of the two would clearly demonstrate how much the dimensions had been multiplied.

2. I took therefore a small glass phial, which would hold about an ounce. Into this phial I poured half an ounce of spirit of wine; for that being the lightest liquid approaches nearest to a pneumatic nature. I then took a very large bladder, which would hold eight pints (or a gallon as we call it in English). The bladder was not an old one; therefore it was neither dry nor stiff, but fresh and soft. Out of this I forced all the air, as well as I could, so that the sides were contiguous and stuck together. I then smeared it outside with a little oil, and rubbed it in gently, that the porosity of the bladder might be closed up by the oil, and likewise that it might become more pliant and yielding. Next I placed the mouth of the phial

within the mouth of the bladder, and tied it tight with a waxed thread; and then put the phial over hot coals in a chafing-dish. In a short time the vapour of the spirit of wine ascended into the bladder, and by degrees inflated it very strongly on every side. On this I immediately removed the glass from the fire, and pricked a hole in the top of the bladder with a needle, that the vapour might rather escape than return into drops. Then I took away the bladder from the phial, and examined by the scales how much of the half ounce of spirit of wine was gone and turned into air. The loss I found was not more than six pennyweights; so that six pennyweights of spirit of wine, which in the body (as I recollect) did not occupy a fortieth part of a pint, when turned into air filled a gallon.

Admonition. I recollect likewise that the bladder, on being removed from the fire, began to shrivel a little; so that notwithstanding so remarkable an expansion, yet the vapour did not seem to be converted into a pure and fixed pneumatic body, seeing it was inclined to recover itself. Nevertheless this experiment may prove fallacious, if we conjecture from this that common air is still rarer than this kind of vapour. For I conceive that spirit of wine made pneumatic (though not pure), yet by reason of its heat exceeds cold air in rarity, because air itself is wonderfully dilated by heat, and considerably exceeds cold air in bulk. I suppose therefore that if the experiment were made with water the expansion would be much less; though the body of water contains more matter than the spirit of wine.

3. If you look at the fume rising from a wax candle

just put out, and measure its thickness by the eye; and again, if you observe the body of that fume when it is rekindled; you will see that the expansion of the flame, as compared with the fume, is about double.

Admonition. If you take a few grains of gunpowder and set them on fire, there is a great expansion compared with the body of the powder. But on the other hand, when the flame is extinguished the body of the fume expands much more. Do not however conceive from this that a tangible body is more expanded in fume than in flame; for it is quite the reverse. The reason of the appearance is, that flame is a body entire, and fume a body mixed in far the greater part with air; and therefore as a little saffron colours a large quantity of water, so a little fume spreads itself over a large space of air. For the fume when thick (as has been said before) and not diffused, appears less than the body of flame.

4. If you take a piece of orange peel (which is aromatic and oily) and squeeze it suddenly near a candle, there spirts out a kind of dew in small drops; which nevertheless makes a very large body of flame as compared with the drops.

Observation.

The conceit of the Peripatetics, that the variety of the elements compared one with the other is in a proportion of ten to one, is a thing fictitious and arbitrary. For it is certain that air is at least a hundred times rarer than water, and flame than oil; but that flame is not ten times rarer than air itself.

Admonition. Let it not be thought that this inquiry and speculation on pneumatic bodies is too subtle or curious. For it is certain that the omission and neglect hereof have paralysed philosophy and medicine, and made them as it were planet-struck; so that they have stood amazed and helpless as far as the true investigation of causes is concerned; attributing to qualities things which are owing to the spirits; as will appear more fully in the proper title of Pneumatic Bodies.

OF THE DILATATIONS AND CONTRACTIONS OF BODIES.

Transition.

So much for the inquiry concerning the bulk of matter in bodies, according to their different consistencies, while they are at rest. But concerning the appetite and motion of bodies, whereby they swell, subside, become rarefied, condensed, dilated, contracted, and occupy more or less space, we must inquire, if possible, still more accurately. For this inquiry is more profitable, as it both reveals and governs nature. Nevertheless it must here be made by snatches, and cursorily; for this title of Dense and Rare is so general, that if it were fully drawn out it would anticipate many of the succeeding titles, which is not fit to be done.

Admonition. It would not be difficult for me to reduce the scattered history (which I shall now subjoin) to a better order than that which I have followed, by placing instances which are related to one another by themselves. But I have purposely avoided this, for two reasons. First, because many

of the instances are of a doubtful nature, and bear upon more than one subject; and therefore accurate order in such things involves either iteration or error. Secondly (and this is the principal reason why I am averse from any exact method), I wish to leave the matter in hand open for every man's industry to imitate. Now if this collection of instances had been arranged according to any scientific and remarkable method, many doubtless would have despaired of being able to make an inquiry of the same kind. By example therefore, as well as by admonition, I warn every man to make use, in procuring and propounding instances, of his own judgment, his own memory, and his own store. Be it enough that invention always proceeds by writing, and not by memory (for that would be something ludicrous in such a variety of instances); so that it may afterwards be perfected by the light of true induction. And let it be ever kept in mind that in this work I only demand a contribution and tax from the sense for the treasury of the sciences; and that I am not proposing examples for the illustration of axioms, but experiments to establish them. But yet in setting forth the instances I shall not neglect arrangement altogether, nor proceed loosely, but I shall so place them that they may mutually shed light on one another.

Scattered History.

1. No wonder if dilatation of a body follows on the reception of another body within it; for this is a direct augmentation or addition, not a true rarefaction. Nevertheless, when the body admitted is a pneumatic

body (as air or spirit), or even when it is a tangible body, if it glide in and insinuate itself gradually, it is commonly regarded as rather a swelling than an addition.

DILATATIONS BY SIMPLE INTROCEPTION, OR THE ADMISSION OF A NEW BODY.

2. Bladders and other tensile bodies (as bellows for instance) are inflated and distended by air alone; so that they become hard, and will bear to be struck and tossed about. A bubble of water also is like a bladder, except that it is so fragile.

3. Liquors poured from above out of one vessel into another, or stirred up violently with spoons, ladles, or winds, are mixed up and united with the air, and thereby rise into froth. But they soon subside and shrink into less space, the air escaping as the little bubbles of froth burst.

4. Children build towers of bubbles from soap and water (the soap making the water more tenacious); so that a very little water, by the introception of air, fills a large space.

5. But it is not found that flame can be mixed with air, and grow frothy by the blowing of bellows or any other agitation from without, so as to constitute a body compounded of flame and air; like froth, which is compounded of air and liquor.

6. But on the other hand it is certain that, by an internal mixture in a body before it is set on fire, a mixed body may be made of air and flame. For gunpowder has uninflammable parts by reason of the nitre, and inflammable parts principally by reason of the sulphur; whence likewise its flame is whiter and paler

than other flames (though the flame of sulphur itself inclines to blue); so that this flame may justly be compared to a most powerful froth composed of flame and air, or to a kind of fiery wind.

7. As froth is a body composed of air and liquor, so likewise are all powders composed of air and small particles of the body pulverised; and therefore they do not otherwise differ from froths than as contiguous differs from continuous. For the great bulk of them consists of air, which raises up the parts of the body; as is shown in the second and third tables.

8. Tumours arise in the stomach and other parts of animals from the introception of wind and watery humour; as in dropsy, tympanites, and the like.

9. There is a kind of pigeon which, drawing back its head within its neck, is inflated and swelled.

10. In respiration the lungs alternately dilate and contract (like bellows) as they draw in and send out the air.

11. The breasts of pregnant women swell with the milky humour.

12. Look in a glass, observe the breadth of the pupil in each eye, and then shut one eye; you will see the pupil of the open eye manifestly dilated, as the spirits which supplied both eyes now flow into one.

13. The cracks of bowls, and in like manner of other woods contracted by dryness, are filled up and consolidated by being kept for a while in water, and soaking it into their pores.

14. There is a kind of fungus (called *Jew's ear*) which grows on trees, that swells exceedingly on being put into water, which sponge and wool do not.

Transition.

And so much for the receptions of one body within another, which are pseudo-rarefactions. I now pass on to dilatations and swellings in bodies from the native spirit (whether they be natural, as they call them, or preternatural), without fire or manifest external heat; though in these cases also there sometimes follows an accession or introception of humour besides the simple dilatation.

DILATATIONS BY THE NATIVE SPIRIT EXPANDING ITSELF.

The History.

1. Must, new beer, and the like, when casked, swell and rise exceedingly, so that unless they obtain a vent they will burst the cask; but if this be given them they rise, and froth up, and as it were boil over.

2. Spirituous liquors close confined, and bottled tight, often burst with great force, and sometimes send out their stopper like a bullet.

3. I have heard that new wine just trodden out, and still fermenting, when put into a strong and thick glass (the mouth of the glass being so closed and sealed that the must could neither burst it nor break through) as the spirit could find no vent, has with continual circulation and vexation completely transformed itself into tartar; so that nothing remained in the glass except vapour and lees. But of this I am not certain.

4. Seeds of plants, as of peas, beans, and the like, swell a little before they put forth root or stalk.

5. Trees sometimes swelling with native juice and spirit burst their bark, and put out gums and tears.

6. Many gems likewise appear to be eruptions of the purer juices from rocks. For both gums and the gems of rocks are shown by their clearness to be filtered and purified juices; so that even rocks and stones seem to swell with a native spirit.

7. No doubt but that in the seed of animals the first act towards vivification is an expansion of the mass.

8. Vitriol in bursting forth as it were blossoms, and almost sprouts like a tree.

9. Stones with time and age (especially in damp places) send out a salt of a nitrous nature.

10. All soil swells with nitre; and therefore any earth covered and heaped up so that its juice is not drawn out by the sun and air, nor consumed in vegetation, collects nitre, as an internal swelling. Hence in some parts of Europe they make artificial mines of nitre by heaping up earth in houses prepared for the purpose, and keeping out the sun.

11. Sweat comes forth in animals when the spirits are dilated by motion, and the humours as it were liquefied.

12. The pulse of the heart and arteries in animals is caused by an endless and alternate dilatation and contraction of the spirits.

13. The voluntary motion likewise in animals, which (in the more perfect) is performed by the nerves, seems to have its root first in the compression and then in the relaxation of the spirits.

14. In animals, on the contusion of any limb a swelling ensues; and the same occurs in most pains.

15. The stings of wasps and bees make a great

swelling for the size of the wound; but that from the bite of a serpent is still greater.

16. Nettles, bryony, and some other things raise the skin, and make blisters on it.

17. It is accounted an evident sign of poison (especially of that kind which operates by malignancy, not by corrosion) if the face or body be swollen.

18. When blisters are applied to the neck or any other part for the cure of diseases, there rises a watery humour, or ichor, which flows out when the skin is cut or pricked.

19. All pustules from an internal cause, and the like excrescences and abscesses, produce apparent swellings, and raise the skin.

20. A sudden burst of anger in some inflates the cheeks, as likewise does pride.

21. Frogs and toads swell; and many other animals when angered erect their combs, hair, and feathers. And this proceeds from a contraction of the skin by the swelling of the spirits.

22. Turkey-cocks swell greatly when angry, and raise their feathers like a mane. Birds while they sleep, the spirit being dilated by the reception of heat into the inner parts, are somewhat swollen.

23. In all decay and putrefaction the native spirits of the body begin to swell; and when they hasten to come forth, they loosen and alter the framework of the body. And if this framework be somewhat tenacious and viscous, so that they cannot escape, they try new forms, as in worms generated from corruption. But the commencement of the action proceeds from the dilatation of the spirits.

24. And the spirit confined in putrefaction produces

not only animal, but also vegetable life; as is seen in moss and the hairiness of some trees. I remember that in summer time I once left by chance a cut lemon in a close room, and two months afterwards I found a putrefaction growing on the cut part; tufts of hair an inch high at least; and on the top of each hair a kind of head, like the head of a small snail, — plainly beginning to imitate a plant.

25. In like manner rust is formed on metals, glass, and the like, from a dilatation of the native spirit, which swells, and presses on the grosser parts, driving and propelling them before it that it may get out.

26. Whether the earth swells in its surface, especially where the soil is spongy and hollow, is a point to be inquired. Certainly in soils of this kind there are sometimes found trees like the masts of ships, lying sunk and buried in the ground several feet deep; so it would seem that these trees had been blown down by storms long ago, and afterwards covered up and buried by the earth gradually raising itself over them.

27. But in earthquakes the earth swells suddenly and manifestly; and oftentimes there burst forth springs of water, wreaths and balls of flame, and strong and strange winds; and stones and ashes are hurled up into the air.

28. But yet earthquakes do not all take place quite suddenly, for it sometimes happens that the earth trembles for several days; and in our time in Herefordshire there was a very small, slow, and partial earthquake, in which some acres of land continued to move gradually for a whole day, and transferred themselves to another place not far off, which lay a little lower, and there rested.

29. Whether the body of waters in the seas sometimes swells is a matter to be inquired. For the tides must needs be caused either by a progressive motion, or by the rising of the water upwards through some magnetic virtue and consent; or lastly by some swelling or relaxation in the waters themselves. And this last (if it be one of the causes of any tide) belongs to the present inquiry.

30. The water in some fountains and wells swells and falls again, so that it would appear to have certain tides.

31. Springs of water likewise sometimes burst out in certain places without any earthquake, at intervals of some years, from causes not known. And such eruption generally occurs during great droughts.

32. It has likewise been remarked that sometimes the sea swells, not at the time of the flood, and with no external wind; and this generally precedes some great storm.

Injunction. It would be worth trying whether there is not sometimes some relaxation in the body of water, even in a small quantity. But if water be exposed to the sun or air, it will more likely be consumed; and therefore the experiment should be made in a closed glass. Take then a glass with a large belly and a long and narrow neck, and fill it with water up to the middle of the neck. But do this in a dry season with a north wind, and leave it till the wind changes to the south and turns wet, and see if the water rises at all in the neck of the glass. Inquire likewise carefully of the swellings of water in wells, whether they take place rather by night than by day, and at what season of the year.

33. In wet weather the wooden pegs of violins swell and become harder to screw. So likewise wooden drawers are harder to pull out, and wooden doors open with more difficulty.

34. The strings of violins break if they are stretched tight in wet weather.

35. Humours in the bodies of animals in wet weather and south winds are found to be relaxed and swell, and to run, and oppress and obstruct the passages more.

36. It is a received opinion that not only in animals, but also in plants, humours and juices swell and fill up the cavities more about the time of the full moon.

37. Salts in damp places dissolve, open, and dilate themselves, as also in some degree do sugar and preserves; which if they are not stored in a room where a fire is sometimes lighted, grow mouldy.

38. All things likewise which have felt the fire and been a good deal contracted are somewhat relaxed by time.

39. The swellings and relaxations of the air should be carefully inquired into, and how far the causes of winds (in any great part) are concerned therein, when vapours are neither collected easily into rain nor dissipated into clear air, but induce swellings in the body of the air.

Transition.

So much then with respect to the dilatations of bodies by the native spirit, whether in maturations or in rudiments of generations, or in excitation by motion, or in natural or preternatural irritations, or in putrefactions, or in relaxations, — being but a few particulars taken out of the heap of nature. I must now

pass on to the openings and dilatations produced by fire and actual external heat.

THE DILATATIONS AND OPENINGS OF BODIES WHICH ARE CAUSED BY FIRE, AND ACTUAL, SIMPLE, AND EXTERNAL HEAT.

Admonition. The openings of bodies by heat or fire (whereof I shall now inquire) belong properly to the titles of Heat and Cold, the Motion of Hyle, and Separations and Alterations. Nevertheless some touch and taste of them must be given in the present title; for without some knowledge of these the inquiry concerning Dense and Rare cannot proceed aright

The History.

1. Air is dilated simply by heat. For there is nothing separated or discharged, as in tangible bodies, but a simple expansion takes place.

2. Cupping glasses are applied to the skin, the glass and the air contained in it having been first heated; presently the air, which has been dilated by heat, begins to cool, and to be gradually contracted into its former state; and then the flesh is attracted by the motion of connection. But if you wish the glass to draw stronger, take a sponge dipped in cold water, and place it on the belly of the glass; thus the air will be further contracted by the coolness, and the attraction will be more powerful.

3. Take a glass and heat it, and afterwards put it into water; it will attract the water so as to fill at least a third part of the space within, which shows that the air was rarefied likewise by the heat as much as a

third of that space. But this is not enough; for the glass I used was so thin that it would not easily bear a greater heat without danger of breaking. But if the phial were of iron or brass, and heated to a greater degree, I conceive the air might be dilated twice or thrice as much, — a thing well worth trying; as also how far the rarefaction can be carried, in order that we may be better able to judge of the rarity of the air in the higher regions, and thence of the ether itself.

4. In thermometers (which so accurately mark the degrees and varieties of heat and cold in the weather) it is clearly shown how small an accession of heat will sensibly expand the air. For a hand laid on the glass, a few rays of the sun, or even the breath of the by-standers will affect it; nay, the inclinations of the external air itself to heat and cold (though imperceptible to the touch) do yet gradually and continually dilate and contract the air in the glass.

5. Hero describes an altar so constructed that when the offering was laid upon it and the fire lighted, water suddenly descended and put out the fire. This required no other contrivance than the making of a close and hollow space under the altar filled with air, which, on being heated and expanded by fire, could find no exit except through a pipe carried up the wall of the altar, and then bent down, with its mouth opening over the altar. Into this pipe (which was made with a belly that it might hold a greater quantity) water was poured. The water was prevented from running out by a cock below, which cock being turned let in the dilated air, which forced up the water and so drove it out.

6. Fracastorius invented a remedy for apoplectic

fits, by placing a heated pan at some distance round the head. For by this means the spirits that were suffocated and congealed in the cells of the brain, and oppressed by the humours, were dilated, excited, and revived.

7. Butterflies likewise, which lie as dead in winter, on being placed before the fire or in the sun, recover life and motion. And persons in fainting-fits are restored as well by hot and strong liquors taken internally as by external heat, friction, and motion.

8. The opening of water proceeds thus: — On the first heat it emits a small and rarefied vapour, without any other perceptible change in the body. If the heat be continued, the water does not rise in its whole body, nor even in small bubbles as in froth, but it ascends in larger and rarer bubbles, and resolves itself into a copious vapour. This vapour, if it be not obstructed or driven back, mixes with the air, being at first visible, then disappearing and losing itself to view.

9. The opening of oil proceeds thus: — On the first heat certain little drops or grains diffused through the body of the oil rise up with a kind of crackling noise. Meanwhile no bubbles play on the surface (as in water), nor does the whole body swell, nor does any exhalation almost escape. But after some time the whole rises and dilates with a manifest expansion to about twice the size, and a very thick and copious exhalation issues forth. This exhalation, unless it catches fire in the meantime, mixes at last with the air, as vapour of water does. Oil however requires a greater heat than water to make it boil, and is much longer in beginning to boil.

10. Spirit of wine opens more like water than oil.

For it boils up in large bubbles without froth or rising of the whole body; but it expands and escapes with much less heat and much quicker than water; and partaking, as it does, of both natures (the watery as well as the oily), it both easily mixes with the air and soon catches flame.

11. Vinegar, verjuice, and wine have this difference in their process of opening; vinegar rises in smaller bubbles, and more about the sides of the vessel; verjuice and wine in larger bubbles, and more in the middle of the vessel.

12. As a general rule, unctuous liquors, as oil, milk, fat, and the like, rise and swell in the whole body at once; ripe juices (and unripe ones still more) in large drops; worn-out and vapid juices in small drops.

13. All liquors, even oil itself, are alike in this; that before they boil they cast up a few half-bubbles here and there about the sides of the vessel.

14. All liquors are alike also in this; that they open, boil, and are consumed sooner in a small quantity than in a large one.

Admonition. The experiment of the opening of liquors should be made in glass vessels, that the motions in the bodies of the liquors may be better seen; upon braziers of an equal heat, that the difference may be more exactly noted; and with a slow fire, because a quick fire precipitates and confounds the actions of bodies.

15. There are a good many bodies, not liquid, but solid and consistent, which yet admit of being opened by heat to such a degree as to melt or become liquid, so long as the heat works and expands them. Such

are wax, fat, butter, pitch, resin, gums, sugar, honey; and most metals, as lead, gold, silver, brass, and copper. They require however not only very different degrees of heat to open them, but also different modifications of fire and flame. For some metals are melted by fire simply, as lead; others, by a fire stirred and blown by bellows, as gold and silver; others require the mixture of some other ingredient, as steel, which does not melt without a mixture of sulphur, or something of the kind.

16. But all these bodies, if a strong fire be continued, not only obtain the opening of colliquation, but pass on to a second opening (namely, that of the volatile, or pneumatic, or of consumption); all, I say, except gold. For as for quicksilver, seeing it is fluid in its own nature, it begins with this second opening, and is easily made volatile. But it is still uncertain whether gold can be made volatile or pneumatic (or even potable as they call it); I do not mean soluble (for that is done easily and commonly by aqua-fortis), but digestible or alterable by the human stomach. Now the true test hereof seems to be, not the raising and thrusting up of it by the force of fire, but such an attenuation and alteration of it that it cannot be again reduced to a metal.

17. Likewise inquire further of glass and vitrified bodies, whether they are consumed by fire, and turned into a pneumatic body. For glass is regarded as a fixed and juiceless body; and vitrification as the death of metals.

18. All bodies that are melted begin the process with the lowest stage of opening; namely, softening and inteneration, before they melt and become liquid

and fusible. Such are wax, gums, fusible metals, glass, and the like.

19. Iron and steel perfected and purified (if they contain no mixture) are not further altered by simple fire, nor proceed beyond this degree of softness; that is, they become malleable and flexible, and lose their brittleness, but do not reach colliquation or fusion.

20. Iron and glass, when opened to the degree of softness of which I have spoken, seem to be dilated in their enclosed spirit; whence arises that action upon the tangible parts, which makes them put off their hardness and obstinacy; and yet the whole body is not seen to dilate or swell locally. Notwithstanding, if you inquire somewhat more closely there will be detected in them plainly a kind of invisible swelling and pulsation of the parts; though it be restrained by the closeness and compactness of their frame. For if you take glass ignited and intensely heated, and lay it on a stone table or some like body (though that table or body be itself also well heated, so that the cause cannot be ascribed to cold), the glass will be broken by reason of the hardness of the stone resisting this secret swelling of the glass. In such cases therefore, when they take heated glass from the fire, they use to lay below it some powder or soft sand, which yields gently, and does not resist the swelling in the parts of the glass.

21. Balls likewise discharged from ordnance, after all external motion of any kind has ceased, and to the eye they appear perfectly immovable, are yet found a long time after to have a tumult and pulsation in their smallest parts; so that if any thing be placed upon them, it will feel a considerable force, and that not so

much from the burning heat as from the tremor of percussion.

22. Fresh wooden staves, when stirred about for some time in hot ashes, assume a softness, so as to be more easily bent. Make trial of this experiment with older staves and canes.

23. Combustible bodies open in this way; by fire they first emit a fume, then catch flame, and lastly deposit ashes.

24. Bodies of a close and compact texture, that contain a watery moisture which abhors flame (as laurel leaves and other non-porous bodies, salts, and the like), open by fire in such a way that the watery and crude spirit contained in them, being dilated by the heat, is emitted with a noise before it catches flame. But if in any body this burst of wind and conception of flame both take place at the same time (a thing which seldom happens), a great tumult and a very powerful dilatation is produced; the wind, like bellows within the body, blowing out and expanding the flame on all sides, as in gunpowder.

25. Bread somewhat swells in the oven, though it loses a little of its weight. And on the top of the loaf there is sometimes a bubble or bladder of crust collected; so that there remains a hollow filled with air between that skin of crust (which they cut off) and the body of the loaf.

26. Meats roasted likewise somewhat swell, especially if the outer skin is kept on, as in sucking-pigs.

27. Fruits roasted sometimes leap out, as chestnuts do; sometimes break their skins and emit their pulp, as apples. But if they be further scorched by the fire, they acquire a kind of coaly crust, so as to leave

a hollow (as in bread) between the crust and flesh of the fruit. And the like occurs in eggs.

28. But if the heat be slow and hidden, and no ready vent be given for the emission of vapour, as in pears roasted in the ashes, and much more in things put into jars and then buried in the ashes; and likewise in meat either baked or stewed; the swelling and dilatation is repelled by the heat, and turned back upon itself; and as in distillation it is restored, and makes the body more moist, and as it were steeped in its own juices.

29. But in dry bodies, if the flame be stifled and find no ready vent, the bodies are rarefied, and become hollow and porous, as in charcoal and pumice-stones discharged from volcanoes.

Transition.

I SHOULD now pass on to the dilatations and openings of bodies by heat in distillations; wherein such openings may be seen more accurately than in cooking and burning. But as it is fit to dwell a good while on these, and as the inquiry thereof properly belongs to the titles of Heat and Cold, of Motion of Hyle, and of Separations, it is but a little that need be propounded in this title.

DILATATIONS BY EXTERNAL HEAT IN DISTILLATIONS.

1. There are two kinds of dilatation, opening, or attenuation of bodies in distillations. The one in passage, when a body is turned into vapour or fume that is afterwards restored; the other in the body restored, which is always rarer, more subtle and expanded, and less materiate, than the crude body from which the

distillation proceeded. For instance, rose-water is rarer and less heavy than the juice of roses.

2. All distillation is performed by a kind of tide or reciprocation, first of rarefaction and version into a pneumatic body, and next of condensation and restoration into a tangible body, as the heat slackens and the vapour is driven back.

3. In distillations the actions of dilatation and condensation are not pure; but that action intervenes (which is the most according to the intention in practice) of the separation of the heterogeneous parts; as the pure juice, phlegm, water, oil, the finer part, and the grosser part.

4. In distillations the degrees and differences of heats are best inquired and determined; as of coals, hot ovens, baths, ashes, hot sand, dung, the sun, fire left to itself, fire blown by the bellows, fire confined and reverberated, heat ascending or descending, and the like; all which contribute wonderfully to the openings of bodies, and especially to the complicated actions of dilatation and contraction, whereof I will speak hereafter. Yet these heats do not appear by any means to be true imitations of that of the sun and the celestial bodies; for they are neither gentle and temperate enough, nor slow and continuous enough, nor sufficiently refracted and modified by intermediate bodies, nor unequal enough in their coming and going. But of all these I will inquire diligently under the title of Heat and Cold, and other appropriate titles.

5. Distillations and through them dilatations are performed in a close vessel where the body to be distilled, the vapours emitted from it, and the air, are shut up together. Yet in common stills and alembics

the outer air is not carefully excluded, but it can to a certain extent find an entrance through the mouth of the still where the liquor passes. But in retorts, when a greater degree of heat is required, no passage is given to the external air, but the mouth of the receiver is fitted so close by luting to the mouth of the vessel (in which the body is put) that the whole process of rarefaction and restitution is performed within. But if the body is full of a vigorous spirit (as vitriol is), it requires a large and capacious receiver, that the vapours may play more freely, and not break the vessel.

Injunctions. 1. Although however distillations are performed as it were in a cell shut in on all sides, yet there is space enough for some parts of the body to expand into vapour, for others to subside into dregs, and also for the vapours to collect and restore themselves, and (if they be heterogeneous) to separate one from the other. The following injunction therefore is of great moment, since it may open a way to the stirring of nature in her inmost parts, and to new transformations. For the Vulcan of chemists and physicians (though it has produced many useful things) has failed perhaps in getting hold of the genuine properties of heat, by reason of the divorces and separations of the parts which always occur in their operations. Therefore the sum of the injunction turns on this; that this separation and alternation of rarefaction and condensation be entirely prevented, and the operation of the heat confined within the barriers of the body itself. For this Proteus of matter will perhaps by this means be manacled and forced to turn itself into all its shapes to get free. On this point many examples

occur to me, and others may perhaps be found; but I will propose one or two of the easiest, merely to make my meaning clear.

2. Take a cubic iron vessel with very strong and thick sides. Put into it a cube of wood made to the perfect measure of the vessel, and which exactly fills it. Make an iron lid no less strong than the sides of the vessel, and lute it up perfectly as chemists do, so as to be as close as possible and fire-proof. Then place the vessel on the fire, and leave it there for a few hours; and afterwards take off the lid and see in what state the wood is. I conceive (seeing it was absolutely prevented both from catching fire and from emitting fume, so that the pneumatic and moist part of the wood could not be discharged) that one of these things must happen: either the body of wood will be converted into a kind of amalgam, or it will be resolved into air or a pure pneumatic body, leaving some dregs (coarser than ashes) at the bottom, and some incrustation on the sides of the vessel.

3. In a like iron vessel make an experiment with pure water, and fill the vessel up to the brim. But let the fire be slower and the time longer; at certain hours also take the vessel off the fire to cool, and repeat the operation several times. I have selected water for this experiment because it is the simplest of all bodies, being without colour, smell, taste, and other qualities. And therefore if by a gentle and temperate heat, an alternation of heat and cold, and a prevention of all evaporation, the spirit of the water not being discharged, and yet worked and attenuated by this kind of heat, shall turn itself upon

the grosser parts of the water, and shall so digest and change them into a new configuration (less simple and uniform), until it either acquires some colour, or smell, or taste, or oiliness, or any other remarkable alteration (such as is found in composite bodies), no doubt a great thing would be achieved, opening the way to many others.

4. With respect to this close distillation (for so I may call that distillation where there is no room for evaporation) any one may devise many other experiments. For I hold it certain that a proportionate heat, operating on the body without separating or consuming the parts, may effect and produce wonderful transformations.

5. But it may be added as an appendix to this injunction, that some method likewise should be devised (which certainly is not difficult) whereby the heat should operate in a vessel not only closed but also tensible, as is done in the natural matrix both of vegetables and animals. For this extends the operation to many things which cannot be accomplished by simple confinement. Neither does this relate to the Pygmies of Paracelsus, or any such monstrous follies, but to things solid and sober. For instance, close distillation will never turn water all into oil, because oil and fat things occupy a greater space than water. But if the operation be performed in a tensible body, this might perhaps be done; and it would be a thing of immense utility, as all alimentation principally consists in fat.

6. It would be good and useful in many respects if in distillations nature were sometimes compelled to give in her account, and an exact estimate were

made how much has been lost, that is, turned into a pneumatic substance, by distillation, and how much remains, whether fixed or restored in the body. This may be done if before distillation you weigh both the body that is to be distilled and the vessels in which the distillation is to be performed, and after distillation you weigh the liquid and the lees, and then the vessels again. From these three weights you will find how much has been restored, how much has remained in the lees, and how much has adhered to the vessels; and from the deficiency of weight in the three as compared with the weight of the whole body, you will find how much has become pneumatic.

Transition.

From the dilatations and rarefactions produced by actual heat I must pass on to the dilatations and relaxations produced by the remission of strong and intense cold; for the remission itself should be regarded as a comparative heat.

The History.

DILATATIONS AND RELAXATIONS OF BODIES BY THE REMISSION OF COLD.

1. Bodies which have been congealed by intense cold, yet not so as to become fixed in their condensation by a continuance of the cold; these, without any manifest heat, and merely by a remission of cold, open and restore themselves; as is seen in ice, hail, and snow. But they do this much quicker if there be some manifest heat applied.

2. But the more delicate bodies, whose vigour con-

sists in a subtle native spirit, as apples, pears, pomegranates, and the like, if they be once congealed, do not afterwards recover their pristine vigour, as the spirit is suffocated.

3. Wine and beer in frost lose their vigour; yet in thaws and south winds they revive, relax, and as it were ferment again.

Transition.

FROM dilatations caused by actual external heat, and likewise by remission of cold (which, as I have just said, is a comparative heat), I must pass on to dilatations caused by potential heats, or by the auxiliary spirits of another body applied and brought into contact.

The History.

DILATATIONS OF BODIES BY POTENTIAL HEAT, OR BY THE AUXILIARY SPIRITS OF ANOTHER BODY.

For potential heats consult the Medicinal Tables of secondary qualities; from which you may extract the things which operate on the human body by dilatation. These are mostly those that follow:

Cardiacs, which dilate the spirits when oppressed.

Abstergents, which strengthen the expulsive faculty.

Aperients, with respect to the orifices of the veins and vessels.

Aperients, with respect to the pores and passages of the parts.

Digestives, which mature.

Digestives, which discuss.

Caustics.

These things especially (for there are others as well) have their root in the dilatation of the spirits, humours, juices, and substance in the body by auxiliary spirits; as well as by the tangible connection with the body which such medicines have, whether taken externally or internally.

Speculation.

It is shown in the thermometer, with how exquisite a sense or perception of heat and cold the common air is endued; since it can discern at once such subtle differences and gradations thereof. And I doubt not but that the spirit of living animals has a still more acute perception of heat and cold; only the air is a pure and genuine pneumatic body, that has nothing tangible mixed with it; whereas the perception of the spirits is blunted and deadened by the tangible body in which they are confined. But yet, notwithstanding this obstacle, the spirits of living animals seem to be superior to the air itself in respect of this perception. For hitherto it has not been proved that potential heat (whereof I am now speaking) can dilate the air; whereas it is certain that it can dilate the spirits contained in the bodies of animals; as appears in the secondary qualities of medicine, which I have mentioned. But of this inquire somewhat more accurately in obedience to this next injunction.

Injunctions. 1. Take two thermometers of the same size. In one of them put water, and in the other spirit of wine, strong and eager; and so heat the glasses that the water and spirit of wine may stand at the same temperature. Place them together, and leave them for a while; and then observe whether

the water stands higher than the spirit of wine. For if this be so, it is evident that the potential heat of the spirit of wine has dilated the air, so as to depress the spirit.

2. It may be useful in many respects, if the operations of the secondary qualities of medicines be sometimes tried and exercised in lifeless bodies. For though it is certain that most of them would be of no effect at all, since by reason of the fineness of the operation, a living spirit is required to actuate them; yet no question but some of them will operate on some lifeless bodies. For we see the effect of salt on meat, of spices on corpses, of rennet on milk, leaven on bread, and the like. If therefore you use attention and judgment, the diligence of physicians with regard to secondary qualities will be of use to perform many other operations; always supposing that a stronger power is required to operate on a dead body than on a live one.

Transition.

I MUST now pass on to the dilatations of bodies which are caused by the liberation of the spirits; that is, when they break out of the prisons of the grosser parts, which had confined them closely, and prevented them from dilating. For in bodies of a compact texture and strongly united in the bonds of their integral nature, the spirits do not perform their work of dilatation, before there be a solution of continuity in the grosser parts by strong corrosive and stimulating liquors with or without heat. And this is shown in the openings and dissolutions of metals, concerning which I will now (as in other cases) propound a few experiments.

The History.

DILATATIONS OF BODIES BY THE LIBERATION OF THEIR SPIRITS.

1. Take a pennyweight of pure gold, reduced into small leaves, so thin that they may be torn by the hand.

2. Take likewise four pennyweights of nitro-muriatic acid, and put them into a glass with the gold. Then put the glass upon a chafing-dish, in which there is a small coal fire. There will soon arise certain little sands or grains, that after a short time diffuse themselves and become incorporated with the liquor, which is thereby made like amber, and bright, and as if dyed with saffron. But in these proportions, only one third of the gold is dissolved by the acid, for the liquor will bear no more; so that if you wish to dissolve the whole pennyweight of gold, you must pour off the part wherein the solution has been made, and pour in four pennyweights more of nitro-muriatic acid, and do this again a third time. This dissolution is performed slowly and calmly with a moderate fire, without fumes, and with no other heating of the glass than by fire.

3. Take any quantity of crude quicksilver with a double quantity of aqua-fortis; put them together in a glass, but do not place them near the fire. Notwithstanding there will soon rise within the body of the water something like a very fine powder, and within an hour, without fire, fumes, or commotion, the mixed body will be turned into clear water.

4. Take one pennyweight of lead in plates to nine

pennyweights of aqua-fortis. The incorporation is not so perfect as in other metals; for the water deposits the greater part of the lead in a calcination at the bottom of the glass, the water itself remaining disturbed, though inclining to be clear.

5. Take one pennyweight of silver, in plates or leaves, to four pennyweights of aqua-fortis; put it in a glass upon a brazier, with a slow fire. The silver rises in grains or bubbles within the body of the water, rather larger than those in which gold rises; it is then incorporated with the water, and both together turn into a fine white liquid like milk. But after the liquid has somewhat settled and cooled, icy particles (either from the metal or the water, or both,) shoot across within the body of the water; and after it has stood a little longer, and settled completely, the liquid clarifies itself and becomes clear and crystalline, the ice being deposited at the bottom. The proportion of silver which the water will bear is the same as in gold; and the dissolution is performed by almost the same heat; nor does it gather heat by motion more than gold.

6. Take one pennyweight of copper in plates to six pennyweights of aqua-fortis. Put them upon a chafing-dish. The copper will rise in still larger bubbles or grains than silver. In a little time it is incorporated with the water, and the united body is turned into a blue, muddy liquid; but after it has settled it becomes clear, of a sky-blue colour, beautiful and bright, the dregs being deposited at the bottom like a small dust, which are themselves however gradually diminished, and ascend and are incorporated with the liquid. Thus these six pennyweights of aqua-fortis dissolve the whole pennyweight of copper; so that the water

will carry twice as much as in the case of gold and silver. But the dissolution of copper conceives a manifest heat by the internal disturbance, even before it is put on the fire.

7. Take one pennyweight of tin in plates to three pennyweights of aqua-fortis; and the whole metal is turned into a body like cream or curds, which does not easily clear, and conceives manifest heat without fire.

8. Take one pennyweight of iron in plates to nine pennyweights of aqua-fortis; without fire the iron rises in large bubbles, not only within the body of the water but above it, so as to boil over the rim of the glass, at the same time emitting a thick and copious saffron-coloured fume; and this too with a very great internal tumult, and a very violent heat, greater than the hand can bear.

Admonition. No doubt but that the different strengths of different kinds of aqua-fortis, and the methods of employing the heat or fire, may likewise cause variations in these openings.

Injunctions. The nature of this dilatation of metals by openings is to be considered; whether it be like the dilatation of gold-leaf, which is a pseudo-rarefaction (as I shall presently explain), because the body is rather dilated in place than in substance, as also is the dilatation of powders; or whether the body itself of the metals be really dilated in substance. The question may be determined by the following experiment. Weigh quicksilver, and take its measure in a prism; weigh likewise aqua-fortis, and take its measure in another prism; then dissolve and incorporate them in the afore-mentioned

manner; afterwards weigh the incorporate substance, and put it likewise into the two prisms, and see if the weight and measure of the composite rightly correspond to the weight and measure of the simples. I have selected quicksilver for the experiment because, as it is dissolved without fire, there is less fear of waste.

Observe (by the way) whether a solution of quicksilver will not bear up very heavy stones, and perhaps tin, so as to make them float. For this may be collected from the proportions of the specific gravities. And this not with a view to marvels and imposture, but to the investigation of the nature of mixtures; as will appear under its own title.

Observation.

It is likewise worth observing (though it does not relate to the present inquiry) that all metals, though a good deal heavier than the waters in which they are dissolved, yet in the first act of dissolution rise in small grains or bubbles. And this is the more remarkable because where fire is not used, as in quicksilver, the same thing takes place.

Speculation.

The tumult in the parts of the body during the dissolution causes them so to ascend. For in a violent corrosion bodies are somewhat impelled by a local motion, as we see in a small pebble of gravel, which being placed in strong vinegar by the side of the vessel (that it may slide more easily), moves backwards and forwards like a little fish. There is likewise a kind of stone or fossil which, on being put into vinegar, moves

restlessly about, and runs hither and thither. But bodies that mix without this tumult do not (as I judge) rise without being shaken; as sugar settled at the bottom of water does not sweeten the top, nor does saffron colour unless it be stirred and agitated.

Transition.

I MUST now pass on to another kind of dilatations, called likewise (in some cases) by the common name of *dissolutions*. This is, when bodies rush to embrace other friendly bodies, and, if they can, open themselves to receive them. But this opening is not made with tumult, or by the penetration of the entering body (as in aqua-fortis), but quietly, and by the relaxation of the receiving body.

The History.

DILATATIONS BY THE EMBRACE AND MEETING OF A FRIENDLY BODY.

1. Sugar and some gums, as gum-dragon, infused in liquids, are melted. For they readily relax their parts (like sponges) to receive the liquid.

2. Paper, thick hair, wool, and porous bodies of the like nature, immersed in liquids or otherwise moistened, so open themselves as to become softer, more easily torn, and as it were rotten.

3. Sudden joys, as good news, the sight of a desired object, and the like, though they do not embrace the body but only the imagination, yet wonderfully dilate the spirits of animals, and sometimes endanger a sudden fainting fit or death. And imagination produces the same effect in the sexual passion.

Injunction. Take thought about finding the menstruums of special substances. For it seems possible that there are liquids and pulps which have such sympathy with certain bodies, that on their application they will readily open their parts and gladly take them in; at the same time intenerating and renewing themselves in their juices. For this bears upon one of the *magnalia naturæ;* namely, the possibility of refreshing and nourishing from without the most radical humours of things, as in flesh, bones, membranes, woods, and the like. There is likewise, even in those things which operate by separation and penetration, a certain sympathy and conformity; as aqua-fortis does not dissolve gold, nor common nitro-muriatic acid silver.

Transition.

I MUST now pass on to dilatations by assimilation or conversion; that is, when the superior and more active body subdues the obedient, obsequious and more passive body, so as to turn it directly into itself, and multiply and renew itself from it. But if the assimilating body be finer and rarer than that assimilated, it is manifest that this assimilation cannot take place without dilatation.

The History.

DILATATIONS BY ASSIMILATION, OR CONVERSION INTO A RARER BODY.

1. Air, especially when it is agitated (as in winds), licks up the moisture of the earth, preys upon it, and turns it into itself.

2. The process of desiccation in woods, plants, and

such like tangible bodies that are not very hard or obstinate, is performed by the depredation of the air, which draws and sucks out the spirit in the body, and turns it into its own substance. Therefore this is done slowly in oily and fat bodies, because their spirit and moisture are not so like the substance of the air.

3. The spirits in tangible bodies (such as I have mentioned) prey on the grosser parts of the body in which they are enclosed. For the spirits which are next the air obey the air itself and go forth soon; but those which are situated deeper in the body prey upon the internal parts that lie near them, generate new spirit from them, take that spirit into themselves, and in the end go forth with it. And hence it is that such bodies lose weight by age and time; for this would not happen unless some part not pneumatic were gradually turned into that which is pneumatic. For the spirit already made in the body does not add, but rather diminishes weight.

4. Many swellings in the bodies of animals are dispersed without suppuration or discharge of matter, by insensible perspiration, being completely turned into a pneumatic body, and escaping.

5. Flatulent foods engender ventosities, their juices being turned into wind, and escape by eructations and the like. They likewise stretch and gripe the internal parts; as also good and approved aliment sometimes does, by reason of the weakness of the functions.

6. In all bodies that take aliment, when the part nourished is rarer than the nourishment (as the spirit and blood in the arteries of animals are lighter than meat and drink), it must needs be that alimentation induces dilatation.

7. Of all openings, dilatations, and expansions, the greatest, as regards the proportion of the body before and after dilatation, the quickest, and the one performed with least delay and most sudden action, is the dilatation of oily and inflammable bodies into flame; for this is done as it were at once and without gradations. And it is plainly (as regards the succession of the flame) of the nature of assimilations; the flame multiplying itself on that which feeds it.

8. But the most potent thing in this kind, not with regard to quickness in first catching flame (for gunpowder does not light so soon as sulphur, camphor, or naphtha) but with regard to the succession of flame once caught, and the overcoming resistance, is that combination of expansions into air and flame (of which I spoke of before), which is found in gunpowder; as appears in guns and mines.

9. Chemists likewise observe a very violent expansion of quicksilver by fire. Nay, gold also, when vexed and confined, sometimes explodes potently, to the great danger of the workmen.

Transition.

I MUST now pass on to the dilatations or distractions and separations which are caused not by any appetite in the body itself which is dilated, but by the violence of external bodies, which, as their motions are the stronger, force another body to dilate and distract itself. Such an inquiry belongs properly to the title of the Motion of Liberty; but (as in the other cases) I will now inquire something concerning it, though sparingly and briefly. This motion is commonly of two kinds; first, the motion of distraction by external

force; secondly, the motion of contraction or restitution by the proper motion of the body; which latter motion, though it belongs to condensations, yet is so connected with the former, that it is more convenient to handle it here.

The History.

DILATATIONS OR DISTRACTIONS BY EXTERNAL VIOLENCE.

1. Wooden staves and the like bear some degree of bending; but only by force. Now the force draws asunder the external parts of the wood in the place where it is bent, and compresses the inner parts. If this force be presently remitted, the stick starts back and restores itself; but if it be kept long in that position it is fixed in it, and starts back no more.

2. There is a similar process in watches (I mean those which are moved by the twisting of steel springs), where you may see the continual and gradual efforts of the steel to restore itself.

3. Cloth and the like thread substances can be stretched to a great extent, and bound back, if they are soon let go; but not so if they are held long.

4. The flesh which rises in cupping-glasses is not a swelling but a violent extension of the entire flesh by attraction.

5. What rarefaction the air is capable of (in proportion to the violence used) may be ascertained by an experiment of this kind. Take a glass-egg with a small hole in it; suck out the air as much as you can: stop the hole instantly with your finger, and sink the egg in water with the hole still stopped. Then take

away your finger, and you will see that the egg will draw in as much water as there was air sucked out; in order that the air which remained may recover its former bulk, from which it had been forcibly distracted and extended. Now I remember that the water filled about a tenth part of the egg. I remember likewise that (after sucking out the air) I left the egg for a whole day closed up with wax, to see if during that time (which certainly was too short for a correct experiment) the dilated air could be fixed, so as no longer to care about restoring itself, as is the case in sticks and cloth. But when the wax was removed the water entered as before; and if the egg instead of being put in water had been applied to the ear, fresh air would have entered with a hissing noise.

6. The rarefaction which water allows of may perhaps be detected in this way. Take a pair of bellows; draw in as much water as the hollow of the bellows will hold; yet do not raise the bellows to their full height, but only about half way. Then stop up the bellows, yet still keep raising them gradually; and you will see how far the water contained within can be dilated. Or in like manner draw up some water through a pipe or syringe; then stop up the hole, and keep on gradually drawing the piston.

Speculation.

I suspect likewise that the spirit of water suffers some distraction in congelation; but the principle of it is subtle. First, it may be held as certain that in all baking (as of clay into bricks and tiles, of bread, and the like) much of the pneumatic part of the body exhales and escapes (as I shall shortly show); and hence

it follows that the grosser parts must, by the motion of connection principally (for there is also another motion of which I am not now speaking), contract themselves. For the spirit being removed, and no other body easily gaining entrance, then, to prevent a *vacuum* (as they say), the parts succeed to the place which was previously occupied by the spirits; and hence this hardness and contraction. Precisely for the same reason it seems to follow contrariwise that the spirits must be distracted in congelation. For the grosser parts are contracted by cold; and therefore some space is left deserted within the confines of the body; whence it follows that if no other body enter, the pre-existing spirit must, by the motion of connection, be as much distracted as the grosser parts are contracted. Indeed it is seen in ice, that the body becomes full of cracks within, and crusted, and a little swollen; and that the ice itself, notwithstanding the remarkable contraction of its parts, is (in the whole) lighter than water itself; and this may be justly attributed to the dilatation of the pneumatic part.

Transition.

I MUST now pass on to dilatations by diffusions, that is, when that which has been heaped up and accumulated is spread out. But such dilatations are to be regarded as pseudo-dilatations; for the dilatation is in the position of the parts, not in the substance of the body. For the body remains of the same density of substance, but acquires a form wider in surface, and less in depth.

The History.

DILATATIONS BY DIFFUSION.

1. Gold by being beaten out is immensely dilated, as in gold-leaf; so likewise by being drawn out, as in silver wire gilt; for the gilding is done in the mass, before it is drawn out.

2. Silver-leaf is likewise made, but not to such an exquisite fineness as gold. The other metals also are dilated by being beaten out into leaf and thin plates.

3. Wax and the like are pressed and moulded into thin coats.

4. A drop of ink in a pen is dilated to form many letters; as also paints and varnish are dilated by a pencil or brush.

5. A small quantity of saffron colours a large quantity of water.

Transition.

And so much for the dilatations, rarefactions, and openings of bodies. It remains now to inquire with a like diligence of the contrary actions, that is, of the contractions, condensations, and closings of bodies. And this part I have thought it right to handle by itself, the rather because all the actions therein are not reciprocal; but some of them are peculiar, and require a separate explanation. And even when they correspond with the other as opposites, yet they are investigated and discovered by very different experiments.

The action of dilatation by the reception of another body has its reciprocal in the action of contraction by

the emission or expulsion of another body; this therefore is to be inquired first.

The History.

CONTRACTIONS BY THE EMISSION OR PUTTING AWAY OF A BODY RECEIVED.

1. Consult the instances of dilatations by introception, and oppose to them the same instances after the dilatations have subsided; I mean in cases where subsidence can take place.

2. Pure and perfect metals, though vexed and altered in various ways, as in sublimations, precipitations, amalgamations, dissolutions, calcinations, and the like, are yet (as the nature of metal does not agree well with that of other bodies) commonly restored by fire and casting, and turned into the same kind of body as before. But this condensation is not genuine, because it seems to be nothing else than an emission and exclusion of the air which had got in, or of the waters in which the metals had been dissolved, in order that the genuine parts of the body of the metal may again unite; yet there is no doubt but that the body occupies far less space than before; only it does not appear to be condensed in substance. And this *power of the keys* to open and shut is most vigorous in metals. Moreover, impure metals, marcasites, and ores are in like manner purified (the homogeneous parts being collected by the fire, and the dross and alloy being emitted and discharged). For all pure metal is denser and heavier than impure.

3. But it tends to make metals more condensed if they are often fused, and often quenched in wa-

ters; whereby they become more hard and stubborn. Whether however their weight increases in proportion to their dimensions has not hitherto been ascertained. Of this therefore make experiment. And this induration is still more potently performed by frequent solutions and restorations, than by fusions and quenchings. Inquire likewise in what kind or mixture of waters metals are most indurated.

4. Methods have been discovered to mortify metals, that is, to prevent them when melted and opened from being again restored. This is best seen in quicksilver; which, if it be beaten up strongly with a little turpentine, saliva, or butter, is mortified, and acquires an aversion and dislike to be restored to its former state.

Injunction. Inquire diligently concerning the mortifications, that is, the hindrances to restoration in all metals. For they must have a great antipathy to those things which prevent them from uniting. And since all restoration is a kind of condensation, a knowledge of the prevention thereof will relate to a knowledge of the form.

The History.

To the dilatations by the expansion of the native spirit there is properly no reciprocal action; for contraction is a thing foreign to the spirit, which is not contracted, except when it is suffocated or worked upon, or when it gathers itself up (like a ram) for a stronger dilatation. Notwithstanding it will be convenient here to substitute that action which belongs properly to the grosser parts, but ought by accident to be imputed to the innate spirit; this is, when by the discharge or emission of the spirit the parts are con-

tracted and indurated. Now the spirit is emitted either in consequence of its own agitation, or from being invited forth by the ambient air, or from being provoked and irritated by fire or heat.

Speculation.

Fire or heat have the same effect on the attenuation and emission of the spirit, and the actions which follow thereon, as time or age. But age by itself is only a stage or measure of motion; and therefore when I talk of age, I mean a virtue and operation composed of the agitation of the native spirit, the air ambient, and the rays of the heavenly bodies. But there is this difference, that fire and strong heat dilate bodies at once, both strongly and visibly; whereas age, like a most feeble heat, dilates them gradually, gently, and invisibly; for thick fumes and vapours are visible, but perspirations not so, as is manifest in odours. Nevertheless the attenuation and rarefaction of bodies by age is more subtle and exquisite than by fire. For fire, by precipitating the action, makes the pneumatic part in the body fly forth rapidly; occasionally also it turns the prepared moisture into a pneumatic body, and then emits it; whence the tangible parts in the mean time diligently and actively close up; and thereby lay hands as it were upon no small quantity of the spirit, and so keep and detain it. But age does not urge the pneumatical part to escape at once, as soon as it has become pneumatical; and therefore this part remaining longer in the body prepares gradually and in order whatever may be digested into a fine substance; the pneumatic body already formed escaping in the mean time quietly and regularly in very small quantities, so as commonly

to anticipate and as it were deceive the constipation of the tangible parts. Hence it is that in dissolution by age there is at the last very little tangible matter fixed and remaining. For that rotten powder which remains for long periods, as the relics of consumption (such as is sometimes found in old tombs and monuments), is indeed almost nothing, and more minute and exhausted than any ashes made by fire. For ashes have likewise a juice, which may be drawn from them, and turned into salts; but this kind of powder has none. But that which concerns the present inquiry, and for the sake of which these things have been said, is this; it is certain that the spirit as long as it is detained in the body melts, intenerates, works upon, and undermines the tangible parts; but after its emission the tangible parts forthwith contract and close up.

The History.

CONTRACTIONS BY THE SHRINKING OF THE GROSSER PARTS AFTER THE EMISSION OF THE SPIRIT.

1. In old age the skins of animals wrinkle, and the members dry.

2. Pears and apples that are kept long gather wrinkles; and nuts are so contracted as not to fill the shell.

3. The outer rind of old cheeses wrinkles up. Wood in beams, posts, stakes (especially if they be put in green) becomes so contracted as to separate and gape. The like happens to bowls.

4. The earth in great droughts is rent asunder, and the surface becomes full of cracks; and sometimes these cracks go so deep as to cause an eruption of waters.

Admonition. Let no one be so idle as to say that this contraction in droughts is nothing else than a consumption of moisture. For if the only action were the escape of the moisture turned into spirit, bodies should remain of their former bulk and dimension, and only become hollow, as pumice-stone or cork; but not be locally contracted and lessened in their dimensions.

5. Clay in the kiln is wrought into bricks and tiles; but if the heat be strong, as in the middle of the kiln, some part of the clay is likewise turned and fused into glass.

6. Wood, if the flame be smothered, is turned into charcoal; which is a matter more spongy and light than wood itself.

7. Most metals set in crucibles among hot coals, and much more in a reverberatory furnace, are turned into a friable matter and reduced to calcination.

8. Many fossils and metals, and some vegetables, are vitrified by a strong fire.

9. All bodies roasted too much turn to cinders, and are contracted into narrower dimensions.

10. Paper, parchment, linen, skins, and the like, are not only wrinkled in parts by fire, but the whole body twists, curls, and rolls up.

11. Linen set in flame and then presently extinguished is turned into a rarefied substance which will hardly flame, but easily catches fire. This is the tinder which we use to raise a flame.

12. Fat bodies, as wax, butter, oil, lard, and the like, become parched, full of sediment, and as it were smoky, by fire.

13. Eggs are contracted by fire, and change their whites from a clear to an opaque whiteness.

14. And further, if the inside of an egg be thrown into good strong spirit of wine it is poached and becomes white. And in the same manner bread put into the spirit becomes toast.

Observations.

1. I have said that as long as the spirit is detained in the body, if it be excited and dilated by fire and heat, so long it agitates itself, endeavours to escape, and softens, intenerates, and melts the tangible parts; and to digest and subdue the parts is the proper work of the spirit. But after the spirit has found an exit and been emitted, then the work of the parts comes in; for these having been vexed by the spirit unite and bind themselves together, as well from a desire of connection and mutual contact as from hatred of motion and vexation. And hence follows contraction, induration, and stubbornness.

2. This process of contraction of the parts by fire has its utmost degree and limit. For if the quantity of matter be so loosened by the violent depredation of the fire that the parts can no longer hold together, then they separate and are turned to ashes and calcination.

Transition.

And so much for contractions caused by the emission of the spirit from bodies, whether it be emitted by age, or fire, or potential heat. But reciprocal to the action of dilatation by actual external heat is the action of contraction by actual external cold. And of all condensations this is the most proper and genuine,

and it would be likewise the most powerful if we had here on the surface of the earth any intense cold. But cold and a remission of heat (for I have thought good here to join them together) condense some things simply without changing their nature; restore (though imperfectly) some that have been rarefied; and completely change and transform others from one nature to another by means of condensation. On all these I must now propound a few observations.

CONTRACTIONS OF BODIES BY ACTUAL EXTERNAL COLD.

1. Air in a thermometer feels the degrees both of heat and cold. In winter time I have placed a kind of cap of snow upon the head of the glass, which, though the air itself was at that time wintry and sharp, yet so increased the cold that the water rose several degrees from the contraction of the air.

2. I mentioned before that the air in the glass was dilated one third by heat, and contracted itself as much on a remission of the heat.

Injunctions. 1. It is plainly worth the trial, whether air dilated by heat can be fixed in that bulk, so that it shall not labour to restore and contract itself. Take therefore a strong glass and heat it strongly; then tightly close up the mouth of it, so that the air may not be able to contract itself; leave it some days so closed up; then put it in this state into water; and when it is in the water open it and see how much water it draws in, and whether it be as much as it would have been if the glass had been at once put into water.

2. Likewise observe in passing (though it rather belongs to the title of Heat and Cold), whether air

so strongly dilated and forcibly detained retains its heat much longer than it would do if the mouth of the glass had been left open.

The History.

1. The stars appear larger in very clear and cold winter nights than in clear summer ones. This is principally in consequence of the universal condensation of the air, which then more inclines to the nature of water; for all things appear much larger under water.

2. Morning dews are, no doubt, vapours which are not fully dissipated and turned into pure air, but hang imperfectly mixed, till by the cold of night, especially in what is called the middle region of the air, they are reflected back and condensed into water.

3. The condensation of rain, snow, and hail is in like manner caused by the cold of the middle region, which (for the most part) congeals vapours higher up than dews. But here two questions meet us which deserve diligent inquiry. The one is, whether these drops are congealed and condensed as they fall, or whether they are first collected and congregated into greater masses of waters, which (by reason of their distance from the earth) hang pendulous in the air, and afterwards being by some violence shaken, break and split themselves into drops; like some water-spouts in the West Indies, which fall as thickly and suddenly as if they had been poured out of vessels. The other is, whether not only vapours (which before were humours and waters, and are only restored), but also a large part of pure and perfect air, be not congealed, completely transformed, and changed into rain and the

rest, by the violent and intense cold of these regions. Of this I will shortly inquire.

4. In distillations moisture is first changed into vapours; these being left helpless after removal from the fire, pressed together by the sides of the still, and sometimes accelerated by an infusion of cold from without, restore themselves again into water and liquid. Such is a familiar illustration of dew and rain.

5. Some metallic bodies, especially quicksilver, when they are made volatile, yet hasten to restore themselves, and are greatly delighted if they fall in with a solid and materiate body. Therefore they easily stick and easily fall off; so that it is sometimes necessary to pursue their vapours with fire, and pass them on from one fire to another, by a regular series of receivers of fire, placed at some distance from one another round the vessel; lest the vapour after ascending, and being somewhat removed from the fire, should restore itself sooner than is expedient.

6. Things which have been melted by fire, after a remission of the heat are again condensed, and become solid as before; as metals, fat, gums, and the like.

7. A fleece of wool by lying long on the ground gains weight; which could not be unless something pneumatic were condensed into something ponderable.

8. In ancient times sailors used to cover the sides of ships at night with fleeces of wool like coverlets or curtains, but not so as to touch the water; and in the morning they would squeeze out of them fresh water for use on the voyage.[1]

9. I likewise found, by an experiment which I made, that by fastening four ounces of wool to a rope, and

[1] Pliny, xxxi. 37.

letting it down into a well twenty-eight fathoms deep, yet so that it did not come within six fathoms of the water, in the space of one night the wool increased five ounces and one dram in weight; and regular drops of water adhered to the exterior of the wool, so that one might in a manner wet and wash one's hands with them. This experiment I repeated several times; and though the weight varied, it was always considerably increased.

10. Stones, as marble and flint, and likewise wooden beams (especially when painted and oiled) manifestly become damp on thaws, and in south winds; so that they seem to sweat, and you may wipe drops of water off them.

11. In wet frosts (called in England *rynes*) there comes a dew on the window-panes in houses; and this more on the inside towards the room than on the outside towards the open air.

12. Breath, which is air first drawn in and then slightly moistened by a brief stay in the cavity of the lungs, on looking-glasses or polished bodies (as gems, sword-blades, and the like), is turned into a roscid substance, which is soon dissipated like a mist.

13. Linen likewise in houses (where there is no fire) collects damp, so as to steam on being placed near the fire.

14. All powders close shut up in cupboards collect damp, so as to stick together and become like clods.

15. The origin of springs and fresh waters from the earth is supposed to be the coagulation and condensation of the air shut up in hollows of the earth; especially of mountains.

16. Mists are imperfect condensations of the air,

being compounded of a very large portion of air, and a small one of watery vapour. In winter these occur on a change of weather from frost to thaw, or *vice versâ*, in summer and spring they are caused by the expansion of the dew.

Injunctions. 1. As the conversion of air into water would be very useful, all instances which tend thereto should be carefully examined. And among other things it should be determined whether the exudations of marbles and the like in south winds and wet weather are mere condensations of the air reflected by the hardness and polished surface of the stones, like breath on a mirror; or whether they partake at all of the juice and internal pneumatic substance of the stone.

2. Trial may be made by laying a linen cloth or piece of wool on the stone; for if then also the stone exudes, the exudation is partly owing to an internal cause.

Speculation.

That the air itself in the upper regions is turned into water is a necessary conclusion from the conservation of things. For it is most certain that the moisture of the sea and land is turned into pure air after it has by time, association, and a plenary rarefaction completely thrown off the nature of vapours. Therefore if there were no reciprocation, that is, if the air in its turn were not sometimes changed into water as water is into air, the supply of vapours, which remain new and imperfectly mixed, would not be sufficient for rains and showers and the renewal of species; but there would be intolerable droughts, conflagration,

violent winds, and swellings of the air from the perpetual multiplication of the air.

17. In the freezing of water the whole body does not diminish in size, but rather swells. Yet there is a manifest condensation in the parts; so that cracks and separations are seen in the body of the ice. Sometimes likewise (if the air get in) hairs and threads and flowers gradually appear. But ice floats in water; so it is manifest that the condensation is not in the whole.

18. Wine freezes slower than water; spirit of wine not at all.

19. Aqua-fortis and quicksilver, I believe, do not freeze.

20. Oil and fat freeze and are condensed, but not so as to become hard.

21. Frost binds up the earth and makes it dry and hard.

22. The poet says of the northern regions that bronze vessels crack there, and robes become stiff.[1]

23. And this likewise happens in wooden tables, especially where the pieces are glued together.

24. Nails also are said by the contraction of cold to fall out of walls.

25. The bones of animals become more brittle in frost; so that at such times they are more easily broken and more hardly cured. In a word, all hard bodies are made more fragile by cold.

26. Waters or juices are manifestly condensed into shining or crystalline stones; as may be seen in subterranean caverns in rocks, where drops of many shapes (like icicles), but fixed and stony, are found

[1] Virg. Georg. iii. 363.: — Æraque dissiliunt vulgo, vestesque rigescunt.

hanging, having been congealed in their slow and gradual fall. But whether the matter of them be entirely water or the natural juice of the stone (or at least a mixture thereof) is doubtful; especially as gems and crystals often rise and grow up on bare rocks (which cannot be attributed to water adhering to them), and do not fall or hang downwards.

27. Clay is manifestly condensed into stone; as appears in certain large stones made up of small pebbles, which are glued together in the interstices of the pebbles by a stony matter well polished, and as hard as the pebbles themselves. But this condensation does not seem to be caused by the cold of the earth, but by assimilation, whereof I will speak presently.

28. There are some waters which condense wood and (as they say) straws and the like into a stony matter, so that the part of the body which is under water is stone, and the part above remains wood, and all in the same body. And this I have myself seen. Inquire more carefully into this, as it may shed a considerable light on the practical part of condensation.

Injunction. It is probable that metallic waters, by reason of the density which they have contracted from metals, may have a petrifying nature. Make trial of this by straws, thick leaves, wood, and the like. But I judge that you should take those metallic waters which are made by frequent washing and quenching rather than by solution of metals, lest the strong and corrosive waters should hinder condensation.

29. In China they make artificial mines of porcelain by burying (several fathoms deep) a certain mass

of proper and prepared cement; which after lying buried for about forty years is turned into porcelain. And these mines are transmitted as an inheritance from father to son.[1]

30. I have heard as an approved fact that an egg which had long lain at the bottom of a moat was found completely turned into stone, with the colours of the white, yolk, and shell perfect and distinct; but the shell was broken in different places, and shining in small grains.

31. I have often heard of the conversion of the white of an egg into a stony matter; but I cannot speak for the truth of the thing or the manner of doing it.

32. It is certain that flame when it is extinguished is turned into something; namely, an after-fume, which is itself turned into soot. But a more careful inquiry should be made concerning the flames of spirit of wine and such like exhalations, to see into what kind of body they are condensed, and what is their after-exhalation. For it does not appear to be fuliginous, as in flames from oily bodies.

Transition.

And so much for the contractions of bodies by actual cold, whether it be in the air, or in waters and liquids, or in flame; and likewise whether it be a simple contraction, or a restoration, or a coagulation and conversion. Next comes the action which is opposed to dilatation by potential heat; namely, contraction by potential cold.

[1] Marco Polo, ii. 77.

The History.

CONTRACTIONS OF BODIES BY POTENTIAL COLD.

1. As the medicinal tables of secondary qualities are to be consulted for the inquiry of potential heat, so in like manner are they to be consulted for that of potential cold. And in them especial notice is to be taken of astringency, repercussion, obstruction, inspissation, and stupefaction.

2. Opium, henbane, hemlock, nightshade, mandrake, and the like narcotics manifestly condense the spirits of animals, turn them into themselves, choke, and deprive them of motion. But make trial whether they have any effect upon dead bodies, by steeping flesh in their juices (to see if any blackness or gangrene be produced); or by steeping seeds and kernels therein (to see if it will kill them, and stop their growing); or by smearing the top of a thermometer on the inside with their juices (to see if they in any way contract the air).

3. In the West Indies there are found, even in sandy deserts and very dry places, large canes, which at every joint or knuckle yield a good supply of fresh water, to the great convenience of travellers.[1]

4. They say that in one either of the Azores or the Canary Islands there is a tree from which water perpetually drops, and further, that a dewy cloud is always hanging over it.[2] Now it would be worth knowing whether there be found in any vegetable a potential coldness sufficient to condense air into

[1] Purchas's Pilgrims, v. p. 913.
[2] Ibid. iv. 1359. The island is Ferro.

water. Make diligent inquiry therefore of this. But I rather think that these are only the jointed canes whereof I spoke.

5. Upon the leaves of some trees (as the oak) which are of close texture, and do not suck in or retain moisture, there are found with us, especially in the month of May, sweet dews like manna, called honey-dews; but whether there be any power of concoction in the leaves, or whether it be that they only easily receive and retain the dew, does not appear.

6. There is scarce any body in which potential cold is so conspicuous as nitre. For as spices and other bodies have a heat perceptible to the tongue or palate (though not to the touch), so likewise nitre has a cold perceptible to the tongue or palate, greater than that of house-leek or any of the coldest plants. Therefore nitre seems a fit subject to try the virtue of potential cold. On this point take the following injunction: —

Injunction. Take a small bladder of as fine a skin as possible. Inflate it and tie it up; steep it in nitre for some days; then take it out and look if the bladder be at all shrunk. If it be so, you may know that the cold of the nitre has contracted the air. Make the same experiment by steeping the bladder in quicksilver. The bladder should be held fast by a string, to keep it down without pressing it.

7. Take an ointment of roses or the like, and pour some vinegar into it; so far from the vinegar making the ointment more liquid, it will on the contrary make it more hard and solid.

Transition.

To the action of dilatation by embracing is opposed that of contraction by flight and antiperistasis. For as bodies open themselves on every side to such as are pleasant and friendly to them, and advance to meet them, so when they fall in with such as are odious and hostile, they fly from them on all sides, and compress and contract themselves.

The History.

THE CONTRACTIONS OF BODIES BY FLIGHT AND ANTIPERISTASIS.

1. The heat of fire seems to be somewhat condensed by antiperistasis, and to become fiercer, as in frost.

2. On the other hand, in the torrid zone cold seems to be somewhat condensed by antiperistasis; so that if any one take shelter under a tree from the rays of the sun, he immediately shivers with cold.

3. This operation of contraction by antiperistasis is attributed, and not altogether wrongly, to the middle region of the air, where the nature of cold collects and unites itself, avoiding the direct rays of the sun from above, and the reflected rays from the earth below. And hence it is that there are great condensations of rain, snow, hail, and the like in those parts.[1]

4. It may be with reason doubted whether opium and narcotics produce stupefaction by potential cold, or by the flight of the spirits. For opium, from its strong smell, its bitterness, its sudorific power, and

[1] Arist. Meteor. i. 12.

other signs, seems to have hot parts. But as it emits a vapour unfriendly and hateful to the spirits, it puts them to flight on all sides, whereby they are coagulated and suffocated.

Transition.

To the action of dilatation by assimilation and conversion into a rarer body is opposed the action of contraction by assimilation and conversion into a denser one. I mean when this is done not by cold either actual or potential, but by the power of a more active body to multiply itself upon one that is more passive. But assimilation to a dense body is not so common, and far less powerful than assimilation to a rare body; because dense bodies are more sluggish and indolent for the work of assimilation than rare bodies.

The History.

CONTRACTIONS OF BODIES BY ASSIMILATION OR CONVERSION INTO A DENSER BODY.

1. I observed above that clay amidst small stones is condensed into a stony matter.

2. The sides of casks condense the lees of wine into tartar.

3. Teeth condense the things which adhere to them from chewing food, and the moisture of the mouth, into scales, which may be scraped and cut off; but these are as hard as the teeth themselves.

4. All hard and solid bodies condense some part of the liquids that adhere to them both at the bottom (where they adhere most) and also on the sides.

5. Whatever aliments are converted into a body

denser than the body of the aliment itself (as the meat and drink of animals are converted into bone, skull, and horn) are manifestly condensed in the assimilation.

Transition.

To the action of dilatation by external violence, either with or against the desire of the body dilated, is opposed the action of contraction by a like external violence, when bodies are placed by those things which act upon them under the necessity of yielding and compressing themselves.

The History.

CONTRACTIONS OF BODIES CAUSED BY EXTERNAL VIOLENCE.

1. Air easily bears some condensation from violence or external compression; but it does not endure much; as is shown in the violent force of winds and in earthquakes.

2. Take a wooden bowl, invert it, and put it into water, forcing it down perpendicularly with the hand. It will carry air with it down to the very bottom, and will not take in any water except a little about the edges, as will appear from the colour of the wetted wood. Now just so much and no more was the condensation or compression of the air. This was remarkably shown in the invention of the diving-bell, which was this. A large concave vessel filled with air was pressed down into the water. It stood on three feet, made of metal, and thick, that it might be better sunk; the feet being not so high as a man. When the

divers wanted to take breath they stooped, put their heads into the vessel, and breathed. By a repetition of this process they continued their work for some time; till the air, which escaped in small quantities every time the head was inserted into the vessel, was diminished almost to nothing.

3. You may ascertain and calculate the amount of condensation which the air will willingly admit of, in this way. Take a basin full of water; put into it a globule of metal, or a stone, which will settle at the bottom. Place a bowl over this globule, either made of metal so as to sink of itself, or forced down with the hand. If the globule be so small that the air will willingly admit of condensation enough to take the globule within the bowl, it will condense itself quietly, and there will be no other motion; but if the globule be larger than the air can well bear, the air will resist, raise up one side of the bowl, and escape in bubbles.

4. You will likewise see from the compression of a bladder how far it may be compressed without bursting; or again from a pair of bellows, first opened and then sealed up; the valve having been first shut. With respect to the condensation of water I made the following experiment. I had a leaden globe made, with very thick sides, and a small hole at the top. This globe I filled with water, and then soldered up the hole (as I remember) with metal. I then forcibly compressed the globe at the two opposite sides, first with hammers and afterwards with a powerful pressing-machine. Now when this flattening had diminished the capacity of the globe by about an eighth part, the water, which had borne so much condensation, would bear no more; the water admitted of no

greater condensation; but on being further squeezed and compressed it exuded from many parts of the solid metal, like a small shower.

5. All violent motion, as they call it, such as that of bullets from guns, arrows, spears, machines, and many other things, is produced by the preternatural compression of bodies and their efforts to restore themselves; which, when they cannot do on the instant, they shift their place. For solid things, especially if they are hard, submit very unwillingly to further compression. But the inquiry of this matter I refer to the title of Motion of Liberty. For, as I have often said, the present title of Dense and Rare only gleans the ears, and does not reap the crop.

6. The more rarefied bodies are, the more easily do they contract themselves at first; but if they be compressed beyond their limits, the more powerfully do they restore themselves, as is shown in flame and confined air.

7. Flame simply compressed (though it be without a blast, as in gunpowder) is yet made more furious; as may be seen in reverberatory furnaces, where the flame is checked, confined, repelled, and curved.

Admonition. To dilatation by diffusion no reciprocal action is opposed; because bodies diffused are not united in mass again, except by being melted together; as in the restoration of metals, of which I have spoken above.

Speculation.

There is likewise, perhaps, another kind of contraction of bodies, not reciprocal, but positive and by itself. For I judge that in the solution of bodies by liquids,

as in the solution of metals, gums, sugar, and the like, the body is to a certain extent received into the liquid; and yet the liquid is not dilated or expanded in proportion to the amount of body received. And if this is the case, there must be some condensation, for there is more body in the same space. Certainly in the solution of metals, if the water has once received as much as it will bear, it dissolves no more, and has no further operation. Now this condensation (if there be any such) I may call contraction of bodies by saturation.

Injunction. Compress ashes as close as you can, and pour water upon them; and observe carefully how much less they are in bulk, after they have taken in the water, than they were before when mixed with air.

Observations.

The efficients of the dilatation of bodies, as revealed in the foregoing inquiry, are nine in number. 1. Reception within, or admission of a foreign body. 2. Expansion, natural or preternatural, of the native spirit. 3. Fire or external actual heat; or even remission of cold. 4. External potential heat, or auxiliary spirits. 5. Liberation of the spirits from the bonds of the parts. 6. Assimilation by the predominance of a rarer body which is more active. 7. Embracing, or going to meet a friendly body. 8. Distraction through external violence. 9. Diffusion or levelling of the parts.

The efficients of the contraction of bodies are eight. 1. Exclusion or deposition of the body received. 2. Shrinking or contraction of the parts after the emission of the spirit. 3. External actual cold, or even

remission of heat. 4. External potential cold. 5. Flight and antiperistasis. 6. Assimilation by the predominance of a denser body which is more active. 7. Compression by external violence. 8. Saturation, provided such a thing be.

The actions of dilatation by the native spirit, by liberation of the spirits, and by diffusion; and again, the actions of contraction by astringency; are actions without reciprocals. The other actions are reciprocal.

Dilatations by reception within, and by diffusion, are pseudo-dilatations; as likewise contractions by exclusion are pseudo-contractions. For they are in place, not in substance.

Expansion by fire or heat without separation is the simplest of all. This takes place in a pure pneumatic body, as air, where nothing exhales and nothing settles, but there is a mere dilatation, and that with a considerable increase of expansion and bulk. Whether there be anything like this in flame; that is, whether flame after the expansion of the first kindling (which is great) being now made flame (where there is great eagerness of circumambient bodies) expand itself still further; is difficult to ascertain, by reason of its quick and momentary extinction; but of this I will inquire in the title respecting Flame. Next to this dilatation (in point of simplicity) is the expansion which takes place in the melting of metals, or in the softening of iron and wax, and the like, for a time, before anything becomes volatile and is emitted. But this dilatation is secret, and takes place within the confines of the integral body, without visibly changing or increasing its bulk. But as soon as anything begins to escape in any body, then the actions become complicated, partly rare-

fying, partly contracting; so that those contrary actions of fire, which are commonly observed,

> As the same fire which makes the soft clay hard
> Makes hard wax soft,[1]

are based on this; that in the one the spirit is emitted, in the other it is detained.

The condensation which is caused by fire, though not a pseudo-condensation (for it is substantial), is yet rather a condensation of the parts than of the whole. For certainly the grosser parts are contracted; yet so that the whole body is rendered more hollow and porous, and of less weight.

Provisional Rules.

1. The sum of matter in the universe is always the same; and there is no operation either from nothing or to nothing.

2. Of this matter there is more in some bodies, less in others, in the same space.

3. Abundance and scarcity of matter constitute the notions of dense and rare, rightly understood.

4. There is a limit of dense and rare which cannot be passed, but not in any body known to us.

5. There is no vacuum in nature, either collected or interspersed.

6. Within the bounds of dense and rare there is a fold of matter, by which it folds and unfolds itself without creating a vacuum.

7. The differences of dense and rare in known tangible bodies do not much exceed the proportions of 32 to 1.

[1] Virg. Eclog. viii. 80.:—

> Limus ut hic durescit, et hæc ut cera liquescit,
> Uno eodemque igni.

8. The difference between the rarest tangible body and the densest pneumatic body is 100 to 1, and more.

9. Flame is rarer than air, oil than water.

10. Flame is not rarefied air, nor oil rarefied water; but they are plainly heterogeneous bodies, and not very friendly.

11. The spirits of vegetables and animals are breaths compounded of an airy and flamy pneumatic body, as their juices are of one watery and oily.

12. Every tangible body with us has a pneumatic body or spirit united and inclosed within it.

13. Spirits, such as those of vegetables and animals, are not found at large with us, but attached and confined in the tangible body.

14. Dense and rare are the proper effects of heat and cold; dense of heat, rare of cold.

15. Heat operates on pneumatic bodies by simple expansion.

16. Heat in a tangible body performs two operations; the pneumatic part it always dilates, but the gross part it sometimes contracts, sometimes relaxes.

17. Now the rule thereof is this; the emission of the spirit contracts and indurates the body; the detention of the spirit intenerates and melts it.

18. Colliquation commences with the expansion of the pneumatic part in the body; but other dissolutions commence with the expansion of the gross part, setting at liberty the operation of the pneumatic.

19. Next to heat and cold, the most powerful agents for rarefaction and condensation are the agreement and flight of bodies.

20. Restoration after violence both dilates and condenses in opposition to the violence.

21. Assimilation both dilates and condenses, according as the thing assimilating is rarer or denser than the thing assimilated.

22. The rarer bodies are, the greater is both the dilatation and contraction they submit to from external violence, within certain limits.

23. If the tension or pressure of a rare body exceed the bounds of endurance, rare bodies free and restore themselves more forcibly than dense ones, because they are more active.

24. The most powerful expansion is that of air and flame united.

25. Dilatations and contractions are imperfect when restoration is easy and at hand.

26. Dense and rare have a close connection with heavy and light.

27. Man is scantily supplied with the means of condensation, by reason of the want of potent cold.

28. Age is like a lambent fire, and performs the work of heat, but more finely.

29. Age brings bodies either to putrefaction or dryness.

Desiderata with their nearest Approximations.

1. Conversion of air into water.

Approximations. Springs in the hollows of mountains. Exudation of stones. Dew formed by the breath. The fleece upon the sides of ships (?). Watery meteors, and the like.

2. Increase of weight in metals.

Approximations. Conversion of iron into copper. Increase of lead in cellars (?). Conversion of quicksilver into gold (?).

3. Petrifaction of earth and other vegetable or animal substances.

Approximations. Petrifying water. Stones made up of an incrustation of small pebbles. Crystal icicles in caves. Stones in the kidneys, bladder, and gall-bladder. Scales of teeth.

4. Various uses of the motion of dilatation and contraction in the air by heat.

Approximations. The thermometer. Hero's altar. The musical instrument played by the rays of the sun. The device for imitating the ebb and flow of the sea and rivers.

5. Inteneration of the members of animals by a proportionate heat and detention of the spirit.

Approximations. Softening of iron. Softening of wax. All amalgamations. This pertains to the renewal of youth; for all moistening besides that performed by the detention of the native spirit seems to be a pseudo-inteneration, and of little effect; as we shall see under its own title.

Admonition. Under this title I propose few desiderata and reminders about practice; for the matter is so general and extensive, that it is more adapted to inform the judgment than to instruct practice.

INQUIRY

RESPECTING

THE MAGNET.

INQUIRY RESPECTING THE MAGNET.

THE magnet attracts powder of prepared steel, such as is used in medicines, and likewise steel reduced by calcination to a very fine black powder, as strongly as crude iron filings; but oxide of iron, which is an artificial rust of iron, it attracts more slowly and feebly. If however the iron be dissolved in aqua-fortis, and some drops of the solution be placed on a flat piece of glass, the magnet neither draws out the iron nor attracts the water in which it is dissolved.

The magnet attracts its own dust in the same way as iron filings; and very small pieces of a magnet will attract one another, so as to hang in thin lines like needles.

Place the magnet at such a distance from the iron that it will not attract it. Put between them a cap of iron, still keeping the same distance, and the magnet will attract the iron; the power of the magnet being better diffused through the iron than through the medium of the air alone.

A magnet put into aqua-fortis, and left there for several hours, does not lose its power.

A magnet rubbed on cloth (as we do with amber),

or on another magnet, or warmed at the fire, is not increased in power.

One magnet has much more virtue than another; and moreover if it be touched with iron, it will transmit its virtue in due proportion to the amount of it; the virtue, I say, not only of verticity, but likewise of simple attraction. For if you take a strong magnet and touch a piece of iron (say a knife) with it, and then touch another knife with a weaker magnet, you will see the iron touched by the stronger magnet attract a greater weight of iron than that touched by the weaker one.

A magnet attracts iron at an equal distance through air, water, wine, and oil.

If a magnet or its powder be immersed in aqua-fortis no solution at all takes place, as happens in iron; though the magnet appears to be a body of a similar substance to iron.

The powder of the magnet does not attract untouched iron, nor touched either; yet the powder is itself attracted by touched iron, and sticks to it; but not by untouched. So that the powder of the magnet appears to retain its passive virtue in some degree, but not its active.

A needle which, laid on a flat surface, is not attracted by the magnet by reason of its weight, will, if placed on the bottom of a glass turned up, so that it hangs over at each side, be attracted; a fact which I think the more deserving of mention, because something of this kind may have given rise to the idle story that adamant hinders the power of the magnet. For place a needle upon a small piece of adamant cut into a square, with a magnet near, but not near enough to

draw it, yet it will tremble. But this trembling is not the prevention of motion, but the motion itself.

A magnet attracts touched iron far more vigorously than untouched; so that the iron, which untouched is not attracted at a given distance, will, if touched, be attracted at thrice that distance.

No iron or metallic matter is extracted from the magnet by fire, or any known means of separation.

A magnet is not dissolved in nitro-muriatic acid any more than in aqua-fortis.

A magnet put into a crucible, yet without any flame, is diminished much in weight, and immensely in power, so as scarce to attract iron.

A magnet hardly turns liquid, but yet it changes its shape a little, and becomes red hot as iron.

A magnet burnt whole retains its passive power, so as to cling to another magnet; but almost loses its active power of attracting iron.

A magnet burnt in a crucible emits a fume, though it be scarcely visible, which will somewhat whiten a sheet of brass laid over it; as likewise do metals.

A magnet in the process of burning penetrates through the crucible, and that too whether it be broken outside or inside, which makes it shine with brilliancy.

All agree that if a magnet be burned to such an extent as to throw out a lurid and sulphureous flame it entirely loses its virtue, and never afterwards recovers it, though it be cooled in a position south and north; an operation which gives virtue to bricks, and renews the power of magnets not completely burnt.

An experiment has been made with magnetised

iron, and likewise with the magnet itself, placed on the top of St. Paul's in London (one of the highest churches in Europe), to see whether their attractive power was diminished in consequence of their distance from the ground; but there was no difference at all.

TOPICS OF INQUIRY

RESPECTING

LIGHT AND LUMINOUS MATTER.

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LIGHT AND LUMINOUS MATTER.

I. *The Table of Presence.*

Observe first, all bodies of every kind which generate light; as stars, fiery meteors, flame, wood, metals, and other bodies ignited, sugar in scraping and breaking, the glowworm, spray of salt-water beaten and thrown about, the eyes of some animals, some kinds of rotten wood, a great mass of snow. The air itself may perhaps have a feeble light suited to the eyes of those animals which see at night. Iron and tin when put into aqua-fortis for solution boil up, and without any fire conceive a strong heat; but whether they emit any light is a point for inquiry. The oil of lamps sparkles in hard frosts; on a clear night a feeble light is sometimes visible about a sweating horse; and sometimes likewise, though seldom, about men's hair, in the shape of a small lambent flame; as happened to Lucius Marcius in Spain.[1] A woman's stomacher was lately observed to shine, but only on being rubbed; this however had been dyed green, a dye in which alum is an ingredient, and it slightly crackled while it glittered. Inquire whether alum glitters on being

[1] Livy, xxv. 39.

scraped or broken; but I suppose it requires a stronger fracture than sugar, as being a more stubborn body. Some stockings have been observed to shine on being pulled off, either from sweat or alum dye. Other instances.

II. *The Table of Absence in the next Degree.*

Observe likewise what those bodies are which do not emit light, and yet have a great resemblance to those which do. Boiling water gives no light; neither does air though violently heated. Mirrors and diamonds, which reflect light so wonderfully, give none of their own. Other instances.

Observe likewise accurately in this kind of instances respecting those that are migratory, that is, where light is present and absent, as it were in passing. An ignited coal gives light, but if it be strongly compressed it at once loses it. The crystalline moisture of the glowworm, at the death of the worm, though broken and divided into parts, retains its light for a short time; but this soon dies away. Other instances.

III. *The Table of Degrees.*

Observe the different intensities and vibrations of different kinds of light. The flame of wood emits a strong light; the flame of spirit of wine a weaker; the flame of coals thoroughly ignited one very dusky and hardly visible. Other instances.

IV. *Colours of Light.*

Observe concerning the colours of light, what kinds there are, and what not. Some of the stars are white, some bright, some reddish, and some lead-coloured.

Common flames are generally saffron-coloured, and among them celestial coruscations and the flames of gunpowder are most inclined to whiteness. The flame of sulphur is a beautiful blue. Some bodies have purple flames. No green flames are yet discovered; the most inclined thereto is the light of the glowworm. Neither are there scarlet flames. Ignited iron is reddish, and when more intensely ignited, whitish. Other instances.

V. *Reflections of Light.*

Observe what bodies reflect light; as mirrors, waters, polished metals, the moon, and precious stones. All liquid bodies and such as have a very smooth and polished surface have some brightness; but brightness is a small degree of luminosity.

Observe carefully whether the light of one lucid body can be reflected by another; as if ignited iron be taken and exposed to the sun's rays. For the reflections of light are reflected again from mirror to mirror, though they become gradually fainter and weaker. Other instances.

VI. *Multiplications of Light.*

Observe the multiplication of light, as by mirrors, perspective glasses, and the like, by which light may be brought to a focus, thrown to a distance, or rendered more subtle and better suited to distinguish visible objects; as we see painters place a glass of water before the candle.

Observe likewise whether all bodies when they are in large quantities do not reflect light. For light (it may be believed) either passes through or is reflected.

Whence the moon, though it be an opaque body,[1] may yet reflect light by reason of its magnitude.

Observe likewise whether an aggregation of lucid bodies multiplies light. In the case of bodies equally lucid this cannot be doubted. But inquire whether a light which is completely overpowered by a greater light, so as to be no longer visible of itself, does not yet add some light. All bright bodies also contribute some light. A room will be lighter hung with silken stuff than with woollen. Light is multiplied likewise by refraction; for gems that are cut in angles, and broken glass, are brighter than if they be even. Other instances.

VII. *Methods of overpowering Light.*

Observe the methods of overpowering light; as by the superiority of a greater light, the grossness and opacity of mediums. Certainly the sun's rays directed on a flame of fire make the flame appear as a white smoke. Other instances.

VIII. *Operations or Effects of Light.*

Observe the operations or effects of light, which are few in number and have little power to alter bodies, especially solid ones. For light above all things generates itself, but other qualities sparingly.

Light certainly somewhat attenuates the air; it is pleasant to the spirits of animals, and exhilarates them; it revives the fading rays of all colours and visible ob-

[1] *Etiamsi fuerit corpus opacum* is the reading both of Rawley's copy and Gruter's. If it be correct, the clause must be understood as parenthetical: "whence the moon (though that indeed is an opaque body) may possibly reflect light by reason of its magnitude alone." It seems more likely however that Bacon meant to write *non fuerit*. — *J. S.*

jects. For all colour is the broken image of light. Other instances.

IX. *Continuance of Light.*

Observe the continuance of light, which appears to be momentary. For light, though it has continued in a room many hours, does not light it any more than if it had been there only a second; whereas in heat and other things it is otherwise. For both the former heat continues and a new one is superadded. And yet the twilight is thought by some to proceed in some degree from the remains of light.

X. *Ways and Passages of Light.*

Observe carefully the ways and passages of light. Light spreads all round; but inquire whether it at the same time ascend a little, or whether it spread equally upwards and downwards. Light itself generates light all round; so that when the body of light is not visible by reason of the interposition of some screen, yet the light itself illuminates all things round it, except those which lie under the shade of that screen. And even these objects are somewhat illuminated by the light diffused around; for they will be much better seen than if there were no light at all. Therefore the visible body of any lucid body and light itself seem to be different things. Light does not penetrate bodies fibrous and of an unequal texture; yet it is not hindered by the solidity of hardness, as we see in glass and the like. Therefore a straight line and pores not lying crossways alone seem to transmit light.

Light is best conveyed by the air; and the purer the air is the better does it transmit light. Inquire

whether light is conveyed by the body of the air. We see certainly that sounds are conveyed by the winds, as you can hear far further with the wind than against it. But inquire whether there is anything similar in light. Other instances.

XI. *Transparency of Lucid Bodies.*

Observe likewise the transparency of lucid bodies. The wick of a candle is seen within the flame, but through larger flames objects are not visible. Nay, on the contrary, all transparency is lost in an ignited body; as may be seen in glass, which on being ignited is no longer transparent. The body of the air is transparent, as likewise is water; but these two transparent bodies when mixed in snow or foam lose their transparency and acquire a kind of light of their own.

XII. *Affinities and Oppositions of Light.*

Observe the affinities and also the oppositions of light. With regard to its generation, light has affinity principally with three things; heat, tenuity, and motion. Observe therefore their unions and separations with respect to light, with the degrees thereof. The flame of spirit of wine or the ignis fatuus is far gentler in heat than ignited iron, but stronger in light: glowworms, the spray of salt water, and many of the things before enumerated, throw out light, but are not hot to the touch. Ignited metals are not rare bodies, yet they have a strong heat: air, on the contrary, is one of the rarest of bodies, yet has no light. Again, air and winds are rapid in motion, but yield no light: whereas ignited metals continue sluggish in motion, and yet emit light.

In the affinities of light which relate not to the generation, but only to the process of it, there is nothing so closely connected as sound. Observe therefore carefully with respect to their sympathies and antipathies. They agree in the following points. Light and sound diffuse themselves all round. Light and sound travel to a very great distance, but light the quickest; as we see in guns, where the light is seen before the report is heard, although the flame comes last. Light and sound admit the most subtle distinctions; witness articulate words in the case of sound; all the images of visible things in the case of light. Light and sound scarce produce or generate anything except in the senses and spirits of animals. Light and sound are easily generated and quickly vanish. For it must not be supposed that the sound which lasts for a time after the striking of a bell or chord is produced by the first percussion. For if the bell or chord be touched and stopped, the sound dies at once. It is manifest therefore that the duration of the sound is generated by succession. Light is overpowered by a greater light, as sound by a greater sound; &c.

Their differences are these: — Light as I have said is quicker than sound. Light travels further than sound. Whether light is conveyed in the body of the air, like sound, is uncertain. Light moves only in a straight line, sound obliquely and in any way; for when anything is seen under the shadow of a screen, it is not to be supposed that the light itself penetrates that screen, but only that it illuminates the air around it; which likewise somewhat brightens the neighbouring air behind the screen; whereas a sound made on one side of a wall is heard without much diminution

on the other. Sound likewise is heard from within a solid body, though more faint; as we see in sounds within the bloodstone, or in bodies struck under water; whereas light in a solid and untransparent body that is stopped on all sides, is not seen at all. Lastly, all sound is generated in motion and a manifest elision of bodies; but light not so.

For the oppositions to light, unless you take privations to mean oppositions, there are none that occur to me; but what is most credible is that sluggishness of bodies in their parts is the chief enemy to light. For there is scarce anything luminous which is not either in its own nature very movable, or excited by heat or motion or the vital spirit. Other instances.

I mean always, not only that other instances are to be sought for (for these few are only adduced by way of example), but likewise that new topics of inquiry should be added, as the nature of things leads the way.

TRANSLATIONS

OF

THE PHILOSOPHICAL WORKS.

PART II.

THOUGHTS

ON THE

NATURE OF THINGS.

THOUGHTS ON THE NATURE OF THINGS.

I.

On the Division of Bodies, Continuity, and Vacuity.

The doctrine of Democritus concerning atoms is either true or useful for demonstration. For it is not easy either to grasp in thought or to express in words the genuine subtlety of nature, such as it is found in things, without supposing an atom. Now the word atom is used in two senses, not very different from one another. For it is either taken for the last term or smallest portion of the division or fraction of bodies, or else for a body without vacuity. With respect to the first, these two positions may be safely and certainly laid down; the one, that there is in things a much more subtle distribution and comminution than falls under view; the other, that this is not however infinite nor perpetually divisible. For if a man observe diligently, he will find that the minute particles of things in continued bodies are far more subtle than those in bodies broken and discontinued. For we see that a little saffron infused and stirred up in water will colour a whole hogshead, so as to make it distinguishable even by the sight from pure water. Now this distribution of saffron in the water is certainly more subtle than that of the finest powder, as will be shown if a similar quantity of powder of Brazil-wood, pomegranate

flowers, or any highly coloured substance, which has not the sequacity of saffron to spread in liquids and incorporate itself with them, be infused in the same way. It was ridiculous therefore to take those small bodies that appear in the sun's rays for atoms. For these are like dust; whereas an atom, as Democritus himself said, no one ever saw or can see. But this distribution of things is shown much more wonderfully in smells. For if a little saffron will tinge and infect a whole hogshead of water with colour, a little civet will infect a suite of two or three large rooms with its odour. And let no one imagine that odours are diffused, like light or like heat and cold, without communication of substance; since he may observe that odours adhere even to solid bodies, as woods and metals, and that for no short time; also that by rubbing and washing they may be dispersed again and cleared away. But in these and similar things, no man in his senses will assert that the process is infinite, seeing this distribution or diffusion is confined to certain spaces, limits, and quantities of bodies; as is most manifestly shown in the above examples. With respect to the second sense of the word atom, namely, that it presupposes a vacuum, and defines an atom as that which is without a vacuum, it was a good and earnest diligence on the part of Hero to deny the existence of a collected vacuum, but maintain that of a vacuum interspersed. For when he saw the constant connection of bodies, and that no space at all could be found or assigned where a body was not; and much more, when he observed that heavy and ponderous bodies are carried upwards, and throw aside and violate their natures, rather than suffer an absolute sep-

aration from the body contiguous to them, he laid it down as certain that Nature abhorred any large or collected vacuum. On the other hand, when he perceived that the same matter of a body was contracted and condensed, and again expanded and dilated, and that it occupied and filled unequal spaces, sometimes larger and sometimes smaller, he did not see how this ingress and egress of bodies in their own places could happen except by means of a vacuum interspersed; less when the body was compressed, and more when it was relaxed. For this contraction must needs happen in one of these three ways; either in that just mentioned, namely, by the exclusion of vacuum in proportion to the contraction; or by the forcing out of some other body previously intermixed; or by some natural (whatever that may be) condensation and rarefaction of bodies. Now with regard to the forcing out of a finer body, that process seems to have no end. It is true indeed that sponges and the like porous bodies are contracted when the air is squeezed out; but it is shown by many experiments that the air itself admits of a considerable contraction. Are we then to suppose that the finer part of the air is squeezed out, and out of that part another, and so on for ever? Such an opinion is strongly opposed by the fact that the finer bodies are, the greater is the contraction they admit of; whereas it should be the contrary, if contraction proceeded from the forcing out of the finer part. And with regard to the other way, namely, that the same bodies, not otherwise changed, do yet admit of more or less in density or rarity, it need not be much laboured. For it seems to be something positive, depending on a supposition incapable of further explanation, as Aristo-

tle's assertions generally do. There remains therefore the third way, which supposes a vacuum. And if a man object to this, that it appears strange and almost incredible there should be a vacuum interspersed when a body is found everywhere, he will, if he calmly consider the examples adduced above of water coloured with saffron or air infected with odours, easily see that there can be no part of the water specified where saffron is not; and yet it is plain, by comparing the water and saffron together before they are mixed, that the body of the water is immeasurably greater than that of the saffron. And if this be found in the case of different bodies, much more must it be supposed to take place in body and vacuity. But in one respect the conjecture of Hero, a mechanical man, was inferior to that of Democritus, who was a distinguished philosopher; for Hero, because he did not find a collected vacuum in our globe, simply denied its existence; whereas there is no reason why in the regions of the air, where there are doubtless greater expansions of bodies, there may not be also a collected vacuum. But in these and similar inquiries men should be once for all admonished, not to be confounded and distrustful in consequence of the exceeding subtlety of nature, but to think that both the units and the sums of things are equally subject to calculation. For it is as easy to talk or think of 1000 years as of 1000 seconds, although years consist of many seconds. Again, let no one think that this is rather a matter of curious speculation than for work and use. For we may see that almost all philosophers and others who have worked diligently in experience and particulars, and cut nature as it were to the quick, are drawn into these inquiries, though

they do not complete them with felicity. And there is no stronger or truer reason why the philosophy we have is barren of effects than this, that it has caught at the subtleties of common words and notions, and has not attempted to pursue or investigate the subtlety of nature.

II.

On the Equality and Inequality of Atoms or Seeds.

The inventions and opinions of Pythagoras were mostly of such a nature as were rather suited to found an order in religion than to open a school in philosophy; and this has been confirmed by the issue. For his discipline has prevailed and flourished more in the heresy of the Manichees and the superstition of Mahomet than with philosophers. Yet his opinion that the world consists of numbers may be so understood as to penetrate to the principles of nature. For there are two opinions, nor can there be more, with respect to atoms or the seeds of things; the one that of Democritus, which attributed to atoms inequality and configuration, and by configuration position; the other perhaps that of Pythagoras, which asserted that they were altogether equal and similar. For he who assigns equality to atoms necessarily places all things in numbers; but he who allows other attributes has the benefit of the primitive natures of separate atoms, besides the numbers or proportions of their conjunctions. Now the practical question which corresponds to this speculative question, and may determine it, is that which was also adduced by Democritus; namely, whether all things may be made out of all things;[1] and as he believed this to

[1] Lucretius, i. 784.

be contrary to reason, he maintained the diversity of atoms. But to me this question does not appear to be well proposed, nor to press the former question, if it be understood of the immediate transmutation of bodies. But the proper question is whether all bodies do not likewise pass through regular circuits and intermediate changes. For there is no doubt but that the seeds of things, though equal, as soon as they have thrown themselves into certain groups and knots, completely assume the nature of dissimilar bodies, till those groups or knots are dissolved; so that the nature and affections of compound bodies may be as great a hindrance and obstacle to immediate transmutation as those of simple. But Democritus, acute as he is in investigating the principles of bodies, when he comes to examine the principles of motions appears to be unequal to himself, and to be unskilful; which likewise was the common fault of all the philosophers. And I know not whether this inquiry I speak of concerning the first condition of seeds or atoms be not the most useful of all; as being the supreme rule of act and power, and the true moderator of hope and works. There is likewise another inquiry flowing from this, which has a less extensive sphere of usefulness, but approaches nearer to things and works. I mean the inquiry concerning separation and alteration; namely, what is done by separation, and what by other means. For it is an error familiar to the mind of man, which has likewise received great strength and increase from the philosophy of the chemists, to impute things to separation, which are due to something else. For instance, when water passes into vapour, one may easily imagine that the finer part of the water is emitted, and the

grosser remains; as we may see in wood, where part escapes in flame and smoke, and part remains behind in ashes. And one may suspect that something of the same kind takes place in water, though not so manifestly. For although the whole body of water sometimes appears to bubble up and evaporate, yet some dregs like ashes may adhere to the vessel. But this consideration is deceptive. For it is most certain that the whole body of water may be changed into air, and if anything do adhere to the vessel, this may not happen from the selection and separation of the grosser part; but perhaps because some part (although of a perfectly similar substance to that which escapes) has from its position touched the vessel. And this is very apparent in quicksilver, which becomes totally volatile, and recovers its former consistency without even the slightest loss. Likewise in the oil of lamps and the tallow of candles the whole of the fat becomes volatile without depositing any ashes; for soot is generated after and not before flame, and is the carcass of the flame, not the sediment of the oil or tallow. And this prepares a way to the overthrow of the theory of Democritus on the diversity of seeds or atoms; a way, I mean, in nature; for in opinion the way is much more easy and inviting, because the common philosophy makes its feigned matter indifferent and agreeable to all forms.

III.

On the Negligence of the Ancients in the Inquiry concerning Motion and the moving Principles of Things.

To rest the inquiry of nature principally on the contemplation and examination of motion is the part of

one who regards works. But to study or feign inactive principles of things is the part of those who would sow talk and nourish disputations. Now by inactive principles I mean those which tell us of what things are made up and consist, but not by what force or in what manner they come together. For with a view to action and the enlargement of the power or operation of man it is not enough, nor indeed of any great use, to know of what things consist, if you know not the ways and means of their mutations and transformations. For to take an example from physicians (from whose notions these celebrated inquiries concerning the principles of things seem to have come), is a man who knows the simple ingredients of treacle, able for certain to make that compound? Or when a man has by him a proper description of the materials used for making sugar, glass, and cloth, would you suppose him on that account to possess the art of preparing and making them? And yet men's speculations are principally occupied in investigating and examining these dead principles; as if a man should make it his object to inspect the anatomy of the corpse of nature, instead of inquiring into her living faculties and powers. But the moving principles of things are treated for the most part only in passage; so that it passes all wonder to see how carelessly and loosely the greatest and most useful thing of all is inquired and handled. For if we consider for a while the philosophies in fashion, will the principle of stimulus of matter by privation, of the shaping of matter according to an idea, of the aggregation of similar particles, of the fortuitous agitation of atoms in a vacuum, of strife and friendship, of reciprocal impressions of heaven and earth, of alliance of the elements by

symbolising qualities, of the influence of celestial bodies, of sympathies and antipathies, of secret and specific virtues and properties, of fate, fortune, necessity, — will, I say, such generalities as these, which are nothing but spectres and appearances that float and play on the surface of things, as on water, enrich mankind or increase their possessions? Such things indeed fill or rather swell the imagination, but they are of no effect towards the accomplishment of works, the mutation of bodies, or the direction of motions. Again, arguments and subtleties concerning natural and violent motion, motion from within and motion from without, and the limits of motions, these likewise lay no hold upon the body of nature, but are rather like writings on the bark. Discarding therefore such matters, or sentencing them to be handed over to popular discourse, we should investigate those appetites and inclinations of things by which all that variety of effects and changes which we see in the works of nature and art is made up and brought about. And we should try to enchain Nature, like Proteus; for the right discovery and distinction of the kinds of motions are the true bonds of Proteus. For according as motions, that is, incentives and restraints, can be spurred on or tied up, so follows conversion and transformation of matter itself.

IV.

On the common Division of Motion, that it is useless and rude.

The division of motion received in philosophy seems popular and without foundation; distinguishing the thing only by effects, and no way conducing to knowl-

edge by causes. For generation, corruption, augmentation, diminution, alteration, carriage to place, are nothing else than the works and effects of motions; which when they arrive at a manifest change of things that is obvious to popular notice are then (in a spirit of contemplation sufficiently dull) distinguished by these names. For I doubt not but what they mean is this; when bodies by motion (of whatever kind it be) have advanced so far as to obtain a new form or lose the old one (which is a kind of period and completion of their course), this is called motion of generation or corruption; but if, the form still remaining, the body only acquires quantity and a new dimension, this is called motion of augmentation or diminution; but if while the size and confines, or circumference, likewise remain, the quality, actions, and passions are changed, this is called the motion of alteration; but if both the form and size and quantity remain, and nothing is changed but the place, this is expressed by the motion of carriage. But all these things, if you examine them more deeply and carefully, are the measure of motion, and periods or courses and as it were tasks of motions; not real differences; for they point out what has been done, but scarce intimate the manner of doing it. Such terms therefore, though necessary for explanation and suited to logical reasonings, are utterly wanting in natural science. For all these motions are composed, decomposed, and composed again in manifold ways; whereas, if we would study nature scientifically, we must find the way to simpler phenomena. For the principles, fountains, causes, and forms of motions, that is, the appetites and passions of every kind of matter, are the proper objects of philosophy; and therewithal

the impressions or impulses of motions, the restraints and reluctations, the passages and obstructions, the alternations and mixtures, the circuits and series; in a word, the universal process of motions. For spirited disputes, probable arguments, vague speculations, or specious opinions, are of little service. But the business is, by proper methods and a course of application suitable to nature, to acquire the power of exciting, restraining, increasing, remitting, multiplying, and calming and stopping any motion whatever in a matter susceptible of it; and thereby to preserve, change, and transform bodies. Now those motions are to be chiefly inquired, which are simple, primitive, and fundamental, whereof the rest are composed. For it is most certain that by how much the more simple motions are discovered, by so much will the power of man be increased and made independent of materials special and prepared, and strengthened for the production of new works. Surely as the words or terms of all languages, in an immense variety, are composed of a few simple letters, so all the actions and powers of things are formed by a few natures and original elements of simple motions. And it were shame that men should have examined so carefully the tinklings of their own voice, and should yet be so ignorant of the voice of nature; and as in the early ages (before letters were invented), should discern only compound sounds and words, not distinguishing the elements and letters.

V.

That the Quantity of Matter is fixed, and that Change takes place without Loss.

That all things are changed, and that nothing really perishes, and that the sum of matter remains exactly the same, is sufficiently certain. And as it needed the omnipotence of God to create something out of nothing, so it requires the same omnipotence to reduce something to nothing. Whether this be done by the failure of the preserving power, or by act of dissolution, is nothing to the purpose; it is enough that the decree of the Creator must necessarily intervene. This being laid down, in order to prevent abstraction of thought, and to show that I do not speak of any fictitious matter, I likewise give notice that the matter introduced by me is such, and invested with such a nature, of which it may be truly said that one body contains more of it, and another (though filling the same measure) less. For example, lead contains more, water less, air much less; and this not in an indefinite and uncertain proportion, but precisely, so that the difference may be exactly calculated, as twice as much, three times as much, and the like. And therefore if a man say that air may be made from water, or *vice versâ*, that water may be made from air, I will listen to him; but if he should say that a given quantity of water may be turned into the same quantity of air, I will not; for it would be the same as saying that something may be reduced to nothing. In like manner, on the other hand, to say that a given measure of air (for instance, a bladder of a certain dimension full of air) may be turned into a like measure of water, is the same as

saying that something may be made out of nothing. From these positions therefore I have now thought good to draw three precepts or counsels for use, in order that men may deal with nature more skilfully, and by that means more successfully. Of these the first is that men should frequently call upon nature to render her account; that is, when they perceive that a body which was before manifest to the sense has escaped and disappeared, they should not admit or liquidate the account before it has been shown them where the body has gone to, and into what it has been received. This, as things now are, is done most remissly, and speculation generally ends with sight, insomuch that men do not know what becomes even of such a common thing as flame; for the idea that it is changed into the body of air is most erroneous. The second is, that when men consider the inexorable necessity there is in the nature of matter to sustain itself, and not to turn or dissolve into nothing, they should omit no way of vexing and working it, if they would detect and bring out its ultimate operations and powers of resistance. This counsel may appear simple enough; who denies it? but yet it seems useful, and there is something in it. Nevertheless let us, if you please, bestow a little observation thereon. Take it then thus. The greatest obstacle which a man meets with, either in operating or in experimenting, is certainly this, that he can scarcely preserve a given mass of matter without diminution or increase of quantity, and at the same time press and work upon it; but it escapes his ultimate force by separation. Now there are two kinds of separation: a part of the matter either escapes, as in decoction, or at least withdraws itself, as in cream. The

intention therefore of a profound and radical change of bodies is no other than this, that matter be by all proper methods vexed, and yet both these separations in the meantime prevented. For then only does matter suffer real constraint, when every way of escape is cut off. The third and last is, that men, when they see alterations made in bodies without any diminution or increase of matter, should first get rid of the mistaken idea which is so deeply rooted, namely, that alteration is caused only by separation; next, they should begin carefully and scientifically to distinguish concerning alterations, when they are to be referred to separations, when only to disorder and a different position of the parts without other separation, and when to both. For when I take a rough and unripe pear in my hands, and squeeze, beat, and work it, and it thereby acquires sweetness; or when amber or a jewel is reduced to an extremely fine powder, and thereby loses its colour, I do not believe that any considerable part of the matter is lost, but only that the parts of the body are placed in a new position. It remains to eradicate one error from the human mind which is of such power, that if it be believed, some of the things I have mentioned may be regarded as desperate. For it is a common opinion that the spirits of things, when they are raised by heat to a more intense degree of tenuity, escape, even in the most solid vessels (say silver or glass), through some secret pores and passages; but this is not true. For neither air nor spirit, though rarefied by the accession of heat, no, nor flame itself, is so ready to attenuate itself, that it can seek or make a passage for itself through those pores. But as water does not pass through a very small hole, so neither does air escape

through these pores. For as air is far rarer than water, so also such pores are far finer than visible holes; nor would there be any use in compressing air in a close vessel if such perspirations were at hand or in its power. But the example which they allege is a wretched or rather a pitiable one, as are most of the speculations of the common philosophy when one comes to particulars. For they say that if a lighted piece of paper be put into a cup, and the mouth of the cup be at once inverted and held over a vessel of water, the water is drawn upwards; because when the flame and the air rarefied by the flame, which had occupied some space, have exhaled through the pores of the vessel, some body must take their place; and that it is the same in cupping-vessels which draw the flesh. Now with regard to the succession of the water or the flesh, they judge rightly; with regard to the cause which precedes it, most unskilfully. For it is not any emission of the body which gives the space, but only a contraction; for the body into which flame relapses fills a far smaller space than the flame before it was extinguished. And hence comes that vacuum which requires a succession. And in cupping-glasses this is shown most plainly. For when men want them to draw more strongly, they touch them with a sponge dipped in cold water, that the air within may be condensed by cold and occupy a smaller space. Therefore men may be easy on that point, and not trouble themselves about the ready escape of the spirits; since it is most certain that even those spirits which they often miss, as odours, tastes, and the like, do not always escape from the place in which they are confined, but are confounded within.

VI.

On Apparent Rest, Consistency, and Fluidity.

That certain bodies appear at rest and deprived of motion, seems correct if applied to the whole or entire body, but if to the parts erroneous. For simple and absolute rest, both in the parts and the whole, there is none; but that which is thought to be so is the effect of some hindrance, prevention and equilibrium of motions. For instance, in garden watering-pots, which are pierced full of holes at the bottom, the water (if the mouth of the pot be stopped up) does not run out at the bottom; and this evidently proceeds from a retractive motion, not from a quiescent nature. For the water tries to descend, as much as if it had the power to do so; but there being nothing at the top of the pot to take its place, the water at the bottom is drawn back and forcibly detained by the water at the top. For if in wrestling the stronger man holds down the weaker, so that he cannot move, yet, if the weaker still resist with all his strength, the motion of resistance is not therefore less, because it does not prevail, and is held fast by the stronger motion. Now this which I say of false rest, as in innumerable things it is useful to be known, so it sheds no small light on the inquiry of the nature of solid and liquid, or consistency and fluidity. For solids seem to be stationary and at rest in their positions, but liquids to move about and be in confusion; for you cannot raise a column or other statue of water as you can of wood or stone. Therefore it is natural to suppose that the upper parts of the water strive (by a motion which they call natural) to flow downwards; but that with the parts of wood it is

different. This however is not true; as there is the same motion downwards in the upper parts of wood as in water; and this would be carried into action, if it were not held and drawn back by a more powerful motion. Now this is certainly the desire of continuity, or the avoidance of separation, which belongs to water as well as to wood, but in wood is stronger than the motion of gravity, in water weaker. For that even liquids participate in this motion is manifest. In bubbles we see the water throw itself into thin films of a hemispherical form to avoid separation. In droppings we see the water, to continue itself, is drawn out and attenuated into a fine thread, as long as there is any water to succeed; but if there be a deficiency in the continuation, then the water forms itself into round drops, whereof the diameter is much greater than the previous thread. In like manner we see water does not readily submit to a very subtle comminution of its parts, since it will not of its own natural weight, without concussion, run out of very fine holes and cracks. Whence it is evident that in liquids there is an appetite of continuity, though a weak one; whereas on the contrary, in solids it is strong, and overpowers the natural motion or gravity. For if a man think that in a pillar of wood or stone the upper parts do not desire to flow downwards, but to support themselves exactly in the same state, he will easily correct his mistake by observing that pillars or the like, if their height be not in proportion to the width of their base, but exceed it, cannot stand, but are borne down by their weight; so that very high buildings must incline to a pyramidal form, and be narrower towards the top. But what that nature is which increases or lessens this desire of

continuity will not easily be found on inquiry. It will perhaps be suggested that the parts of solids are denser and more compact; the parts of liquids rarer and looser; or that liquids have a spirit which is a principle of fluidity that is wanting in solids, and the like. But neither of these is in accordance with truth. For it is manifest that snow and wax, which may be cut and moulded and take impressions, are far rarer than quicksilver or melted lead, as is proved in the proportion of their gravities. But if a man still insist that snow or wax, though rarer (in the whole) than quicksilver, may yet have closer and more compact parts; but that because their bodies are spongy, and have many cavities, and admit the air, they are therefore in the whole lighter; as is the case in the pumice-stone, which in proportion to its size may perhaps be lighter than wood, yet if both be reduced to powder, the powder of pumice-stone will be heavier than that of wood, because it has now lost its cavities; his observations and objections are good. But what will they say to melted snow and wax, where the cavities are already filled up? or what to the bodies of gums, mastich, and the like, which have not these manifest cavities, and yet are lighter than many fluids? Now what they allege of the spirit, the power and force whereof make things flow, is certainly at first sight probable, and familiar to common notions; but in reality it is more difficult and erroneous, as being not only not supported by reason, but almost opposed to it. For this spirit they talk of does in fact (though it may appear strange) produce consistency, and not fluidity. And this is excellently shown in the instance of snow, which though a body compounded of water and air, and though air

and water separate are fluids, yet acquires consistency by mixture. But if a man object that this may perhaps proceed from a condensation of the watery part by cold, and not from the interposition of the air, he may correct his opinion by observing that foam also is a body like snow, which yet is no way condensed by cold. But if he still urge that in foam likewise condensation proceeds not from cold, but from agitation and percussion, let him look at the boys who, out of a little air breathed through a pipe or tube, and water mixed with a little soap, to make it more tenacious, raise a wonderful tower-like fabric of bubbles. But the fact is that bodies, at the touch of a body that is friendly or similar, resolve and open themselves; but at the touch of an unfriendly body they shrink up and gather themselves together. And hence the apposition of an alien body is the cause of consistency. Thus we see that when oil is mixed with water, the transparency which existed before both in the oil and the water is to a certain extent lost. On the other hand, we see that paper moistened with water resolves itself and loses its consistency (which before by reason of the air in its pores was strong); but moistened with oil it does it less, because oil agrees less with paper. The same likewise we see in sugar and like bodies, which relax themselves to receive water or wine, and that not only when the liquids press upon them, but they likewise suck and draw up the liquids themselves.

VII.

On the Consent between Sensible and Insensible Bodies.

The passions of bodies which have sense, and of bodies without sense, have a great correspondence,

except that a sensible body has also a spirit. For the pupil of the eye is like a looking-glass, or water, and receives and reflects the images of light and visible bodies in the same manner. The organ of hearing has a conformity with an obstruction in a cave, from which the voice and sound is best re-echoed. The attraction of things inanimate, and again the horrors and aversions (I speak of such as are proper and peculiar) in animals, correspond to the sense of smell and pleasing and disagreeable odours. In the taste and touch we find every kind either of violence on the one hand or of gentle and friendly insinuation on the other which can happen in inanimate bodies, with all the configurations of these same passions, expressed and interpreted. For in dead bodies compressions, extensions, corrosions, separations, and the like are concealed in their process, and only perceived in their manifest effects. But in animals they are performed with a sensation of pain, according to the different kind and character of the violence, the spirit pervading everything. And from this principle is derived the knowledge whether any animal may possibly have some other sense besides those observed; and how many, and what kind of senses there may be in the whole race of animals. For a just distinction of the passions of matter will give the number of senses, provided only that the requisite organs be supplied, and the spirit be added.

VIII.

On Violent Motion, that it is the flight and dispersion of the parts of a thing from pressure, though not visible.

Violent motion (as they call it), whereby projectiles, as stones, arrows, bullets, and the like, fly through the

air, is about the commonest of all motions. And yet in the observation and inquisition hereof men have shown a strange supineness and negligence; nor is it a small loss that is entailed by miscarriage in the investigation of the nature and power of this motion; seeing it is of use in infinite ways, and as the life and soul of artillery, engines, and the whole business of mechanics. Now most inquirers, when they have pronounced this motion to be violent, and distinguished it from natural motion, think they have done. And it is indeed the peculiar manner and discipline of Aristotle and his school, to teach men what to say, not what to think; and how to discharge themselves by affirming or denying, not how to explain and satisfy themselves in thought. Others use a little more diligence, and taking up the position that two bodies cannot be in the same place, conclude that the stronger impels, and the weaker gives way; that this giving way or flight, if the force applied be small, does not continue after the cessation of the first impulse, as in protrusion; but that if the force be great, it continues for a time even after the removal of the impelling body, till it is gradually diminished, as in throwing. And these again, after another inveterate habit of the same school, catch at the beginnings of things, but do not trouble themselves about their process and end; as if every beginning implied the rest; and hence, in a kind of premature impatience, they break off the inquiry. For upon the point that bodies yield at the instant of the stroke, they have something to say; but why, after the impelling body has been removed, and the necessity for the disarrangement of the bodies has thereby absolutely ceased, the motion should still continue, they say

nothing, nor do they clearly understand themselves. Others, more diligent and perseverant in inquiry, having observed the power of the air in winds, and the like, which is so great that it can even blow down trees and towers, imagined that the force which carries and accompanies projectiles after the first impulse should be attributed to the air collecting itself and rushing in behind the body moved, by which force the body is carried forward like a ship in the water. And these certainly keep to the point, and carry their speculation to its issue; yet they fail of the truth. Now the case is really this. The principal motion seems to be in the parts of the body projected, which being too subtle to be perceived by the eye, and men not being attentive enough but passing the matter by with a light observation, is not observed. But to an accurate observer it is manifest that hard bodies are most impatient of pressure, and have, as it were, a very acute perception thereof; so that when forced ever so little out of their natural position, they strive with great velocity to free themselves and return to their former state. And to do this, all the parts, commencing with the part struck, thrust and press one another forward, just like an external force; which produces a continuous and intense (though invisible) trepidation and commotion of the parts. And this we see in glass, sugar, and brittle things of the like nature; which, if they be cut or divided with any sharp iron instrument, directly and almost instantaneously break to pieces in other places untouched by the stroke of the instrument; which plainly proves that the motion of pressure is communicated to the neighbouring parts; which motion, working all round, and making trial everywhere, causes

fracture in that part, where from the predisposition of the body the union was weakest; and yet this very motion, while it disturbs and penetrates every part, does not show itself to the eye until there is an open fracture or solution of continuity. Again, we see if a piece of iron wire, or a stick, or a quill (or such like bodies as are flexible and yet elastic) be bent, and held by both ends between the finger and thumb, it immediately leaps away. Now the cause of this motion is proved manifestly not to lie in the extreme parts of the body, which are held fast by the fingers; but in the middle, which bears the violence; to relieve which this motion is set at work. But in this example it plainly appears that the cause of motion they derive from the impulse of the air is excluded; for there is no percussion to set the air in action. And this is also shown in the trivial experiment of squeezing a fresh and slippery plum-stone between the fingers, gradually increasing the pressure, and so shooting it out. For in this example likewise, compression takes the place of percussion. But the most evident effect of this motion is seen in the perpetual revolutions or rotations of projectiles in their flight; for they go forward, but their progress is in spiral lines, — that is, revolving as they go. And certainly I have felt some doubt as to this spiral motion, so rapid as it is and yet so free and as it were familiar to things, whether it did not depend on some higher principle. But I think the cause of this effect is the same that I am now speaking of, and no other. For pressure of a body at once excites a motion in the parts or particles to extricate and free themselves in any way they can. And hence the body is not only driven in a straight line, and so flies forward;

but it tries all round, and therefore revolves; for both motions help to set it free. And in solid bodies this is something subtle and abstruse; in soft bodies it is evident, and almost palpable. For as wax or lead, and similar soft bodies, on being struck with a hammer, give way not only forwards, but on all sides; so hard or resisting bodies fly both in a right line and round about. For the corporeal yielding in soft bodies and the local yielding in hard proceed on the same principle; and it is in the change of shape of a soft body that we can best perceive what the passion of a hard body is when it escapes and flies. Meantime, I would not be understood to deny that, besides this motion (which is the principal thing), some part of the work is also to be attributed to the conveyance of the air, by which the principal motion may be assisted, impeded, turned, and directed. For of this too the power is not inconsiderable. And this explanation of violent and mechanical motion (which has hitherto escaped observation) is as the fountain of practical operation.

IX.

On the cause of Motion in Fire-arms, that it has only been inquired in part, and that not the principal one.

The cause of fire-arms, and the explanation of so powerful and noble a motion is imperfect, and deficient in the most important part. For they say that gunpowder, when converted into flame and rarefied, dilates itself, and fills a larger space; and hence follows, — as otherwise either two bodies would be in one place, or there would be a penetration of dimensions, or the form of the element would be destroyed, or the situation of

the parts would be contrary to the nature of the whole (for these are the phrases used), — the expulsion or breaking out of the opposing body. And there is something in what they say. For this appetite and passion of matter has likewise some part in this kind of motion. Nevertheless they are wrong in too hastily referring the matter to this necessity of dilatation of the body, without distinctly considering that which in nature precedes. For that the body of the powder after it is turned into flame should occupy a larger space, is indeed necessary; but that the body of the powder should catch flame, and that too with such rapidity, is not so, but depends on the preceding conflict and relation of motions with one another. For no doubt but that the solid and heavy body, which is driven out or removed by a motion of this kind, resists sedulously before it gives way; and if it be stronger it gains the victory; that is, the flame does not drive out the bullet, but the bullet smothers the flame. Therefore if in place of gunpowder you take sulphur, camphor, or like things, which themselves soon catch fire, and if (since compactness of bodies is an impediment to kindling) you make them up into grains of powder mixed with some portion of the ash of juniper, or some other very combustible wood, yet (if there be no nitre) that rapid and powerful motion will not follow, but the motion of kindling will be hindered and restrained by the mass of the resisting body, and will not develop itself or take effect. But the truth of the matter is this. You will find that the motion here inquired is double and compound. For besides the motion of kindling, which is principally in the sulphur of the powder, there is another stronger and more violent. This proceeds from

the crude and watery spirit, produced mostly from the nitre, and in some degree from the charcoal of willow-wood, which is not only expanded (as vapours usually are by heat), but also (which is the chief point) flies and bursts away from the heat and inflammation with the utmost rapidity and violence, and thereby likewise makes a passage and opening for the inflammation. We see some rudiments of this motion in the crackling of dry leaves of laurel or ivy when they are put on the fire; and still more in salt, which more resembles the nature of the thing here inquired. Something like it also we often see in wet tallow-candles and the flatulent flames of green wood. But it is especially visible in quicksilver, which is an exceedingly crude body, and like mineral water, the force whereof (if it be vexed by fire and prevented from escaping) is not much less than that of gunpowder. Therefore men should be admonished and entreated by this example, not to seize some one point in the inquisition of causes and thereupon lightly pronounce, but to look about them, and fix their considerations stronger and deeper.

X.

On the Dissimilarity between Celestial and Sublunary Bodies with regard to eternity and mutability; that it is not verified.

The common idea that the universe is rightly divided and distinguished as it were by globes, so that there is one system of celestial and another of sublunary bodies, seems to have been introduced not without reason, if only it be held with moderation. For no doubt but that the regions above and below the

lunar orb, together with the bodies contained therein, differ much and greatly. And yet this is not more certain than that the bodies of both globes have common inclinations, passions, and motions. We should therefore follow the unity of nature, and rather distinguish than sever such things, and not make a breach in the contemplation of them. But what is further held, — that celestial bodies do not suffer changes, while sublunary or, as they call them, elementary bodies do; that the matter of the latter is like a harlot, always seeking after new forms, while that of the former is like a matron, delighting in a wedlock constant and undefiled, — seems a weak and popular opinion, arising out of superficial appearances and superstition. To me indeed it appears to be untenable and without foundation on both sides. For neither is heaven indued with that eternity which they suppose nor the earth with that mutability. For with regard to the heaven, we may not conclude that there are no changes there, because there are none which we can see; for the sight is defeated both by subtlety of the body and distance of place. For there are manifestly various changes of the air, as in heat, cold, odours and sounds, which are not subject to sight. And I suppose that if the eye were placed in the moon's orb, it would not be able at such a distance to see what was going on here, and all the motions and changes of machines, animals, plants, and the like (which by reason of the distance are not as big as the smallest mite), on the surface of the earth. But that in bodies of so great size and magnitude as by the bulk of their dimensions to overcome such a distance and reach the eye, changes do take place within the heavenly regions, is sufficiently proved by some

comets; I mean those which have preserved a certain and constant configuration with the fixed stars; like that which in our day appeared in Cassiopea. But with regard to the earth, when we have penetrated into the interior, and got through that crust and composition which is found on the surface and in the parts next it, there seems a perpetuity there also, like that supposed to exist in the heavens. For doubtless if the earth were subject to changes far within, the consequence of those changes would even in this region which we inhabit produce greater accidents than we see take place. Certainly most of the earthquakes and eruptions of water or fire do not rise from any great depth, but close at hand; seeing that they occupy a small part of the surface. For the wider the district and region such accidents extend over on the face of the earth, the deeper must we suppose their roots or sources to descend into its bowels. Therefore the greater earthquakes (greater I mean in extent, not in violence), which happen seldom, may be rightly compared to the comets of which I spoke, that are themselves likewise uncommon; so that it is true, as I said at first, that between the heavens and the earth, as regards constancy and change, there is no great difference. But if any one be moved by the apparent equability and certainty of motion in the heavenly bodies, as being the inseparable companion of eternity; look at the ocean, which in its ebb and flow exhibits a constancy almost as regular. Lastly, if a man still urge, that yet it cannot be denied but that on the surface of the earth itself and the parts next thereto there are innumerable changes; in the heavens not so; — I would answer, first that I do not mean that they are equal in everything; and yet, secondly, that

if we take the regions which they call the upper and middle region of the air for the surface or inner coat of the heavens, in the same manner as we take this region here in which animals, plants, and minerals are contained, for the surface or outer coat of the earth, we shall find there also various and multiform generations and changes. Therefore almost all tumult, conflict, and disorder seem to have place only in the confines of heaven and earth. As it is in civil affairs, wherein it commonly happens that the border country of two kingdoms is harassed by continual incursions and violence, while the interior of both kingdoms enjoys peace, security, and profound tranquillity. Nor will any one object to this opinion, if he consider it rightly, on the ground of religion. For it was only heathen arrogance that endowed the heaven with this prerogative of being incorruptible; whereas the Holy Scriptures assign eternity and corruption to heaven and earth alike, though not to each an equal glory and veneration. For if we read, "that the sun and moon are faithful and eternal witnesses in the heaven," we read likewise that "generations pass away, but the earth remaineth for ever." But that both are transitory is implied in one oracle, namely, "heaven and earth shall pass away, but the word of the Lord shall not pass away." And these things I have spoken not out of zeal to introduce a new opinion, but because I foresee, not without experience, but instructed by example, that these fabulous divorces and distinctions of things and regions, beyond what truth admits of, will be a great obstacle to true philosophy and the contemplation of nature.

ON THE

EBB AND FLOW OF THE SEA.

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THE consideration of the causes of the ebb and flow of the sea, attempted by the ancients and afterwards dropped, taken up again by the moderns and yet by variety of opinions rather unsettled than discussed, is commonly by a light conjecture referred to the moon, by reason of some correspondence, between the motion of the tides and that of the moon. But yet if we look more closely we shall find some vestiges of truth which may lead to greater certainty. Therefore that there may be no confusion, we must first distinguish the motions of the sea, which, though some have very inconsiderately multiplied them, are in reality only five in number; whereof one is a kind of anomalous motion, the others constant. Let the first motion be set down as that wandering and various motion of the currents (as they call them). The second as that great motion of the ocean every six hours, by which the waters alternately approach and retire from the shore twice a day; not exactly, but with such a difference as makes the period of revolution a month. The third as the monthly motion itself, being no other than the restoration of the daily motion (before mentioned) to the same times. The fourth as the half-monthly motion, whereby the tides are increased more at the new and full

moons, than at the quarters. The fifth as the half-yearly motion, whereby the tides receive a great and remarkable increase at the equinoxes. Now it is of the second, or great diurnal motion of the ocean I intend principally to discourse at present; only touching on the others in passing, and as far as they tend to explain this motion. First therefore with respect to the motion of the currents, there is no doubt but that accordingly as the waters are either confined by straits, or released by open spaces; either run and as it were pour down declivities, or encounter and run up acclivities; either glide smoothly over a level, or are disturbed by the furrows and inequalities of the bottom; either fall in with other currents with which they mingle and are carried along, or are agitated by the winds, especially the anniversary or periodical, which return at certain seasons of the year; there is doubt, I say, that from these and similar causes waters vary their forces and eddies as well in the direction and course as in the velocity or measure of the motion, and that thence these currents are formed. In seas therefore the depth of the channel, the intervention of submarine rocks, chasms, the windings of shores, promontories, gulfs, straits, scattered islands, and the like, produce many effects, and drive the courses and streams of the waters to all points of the compass, to east and west, as well as to north and south, according to the positions and relative configurations of these obstructions, open spaces and declivities. Let therefore this particular and as it were fortuitous motion of the waters be set aside, that it may not confuse us in the inquiry which we are pursuing. For it is not fair to deny the truth of what I shall presently propound with regard to the natural

and universal motions of the ocean, on the ground that this motion of the currents is at variance with my positions. For currents are mere compressions of water, or liberations from compression; and are (as I have said) particular and respective to the positions of water and land, or even to the pressure of the wind. And this should be the more remembered and observed, because this general motion of the ocean, whereof I am now treating, is so mild and gentle, that it is entirely subdued and overpowered by the force of the currents, and yields to the impulse and direction of their violence. Now that this is so, is principally shown by the fact, that the simple motion of the ebb and flow of the sea is not felt in the middle of the sea, especially in vast and extensive seas, but only near the shores. Therefore no wonder if (being inferior in strength) it is hidden and as it were destroyed by the currents; except that this very motion, when it is with the stream of the currents, somewhat assists and increases their force; whereas when it is against the currents it slightly checks it. Dismissing then the motion of the currents, I go on to the four constant motions, the six-hourly, the monthly, the half-monthly, and the half-yearly; whereof the first alone seems to move and stir the flow of the sea, the second only to determine and restore that motion, and the two last to increase and strengthen it. For the ebb and flow of the sea, which floods the shores to a certain distance and then retires again, varies both at different hours and in the force and quantity of water, whereby the other three motions become visible. This motion therefore of ebb and flow must (as we propose) be distinctly and properly considered. And first it must absolutely be

granted, that this motion concerning which we are inquiring be one of these two, — either a motion of rising and falling of the waters, or a motion of progression. Now by motion of rising and falling I mean such motion as is found in boiling water, which rises up in the boiler and then sinks again; whereas by progressive motion I mean such as is found in water carried in a basin, which runs from one side up against the other. But that this motion is not of the first kind appears principally from this, that in the different parts of the world tides vary in point of time; so that in some places there is a flow and increase, when elsewhere there is an ebb and decrease. Now, if waters did not move from place to place but boiled up from the bottom, they ought to rise and fall everywhere at once. For we see that those two other motions, the half-monthly and the half-yearly, act and operate over the whole world at the same time. For the flow of the tide is increased everywhere at the equinox, not in some places at the equinox and in others at the tropics; and so it is with the half-monthly motion. For the tide is highest at the new moon everywhere, and at the quarter nowhere. In these two motions therefore the waters really seem plainly to rise and fall, and to have, as it were, their apogees and perigees like the celestial bodies. Now, in the ebb and flow of the sea, of which I am speaking, it is quite the contrary; which is the surest sign of motion in progression. Besides, if the flow of the tide be set down as a rising, we must observe somewhat more carefully how this rising is caused. For the swelling must be caused either by an increase in the quantity of water, or by an extension or rarefaction of the water in the same quantity, or by a simple lifting

up in the same quantity and the same body. But this third cause is to be absolutely rejected. For if the water be lifted up as it is, there must of necessity be a vacuum between the ground and the bottom of the water, since there is no body to take its place. And if there is a fresh body of water, it must emanate and spring from the earth. But if it be only an extension, that will be caused either by a solution into a rarer body, or by a desire of approaching some other body, which, as it were, summons out and attracts the water and raises it up. And certainly this, whether it be ebullition or rarefaction, or agreement of the waters with some one of the higher bodies, does not appear incredible, if it be in a moderate quantity, and a tolerable length of time likewise be allowed for the swelling or increase of the water to collect and rise. Therefore the excess of water observable between the ordinary tide and the half-monthly which is fuller, or even the half-yearly which is fullest of all, — seeing that it is not greater than the difference between the flow and ebb, and has likewise a long enough interval to make this increase gradually, — is nothing contrary to reason. But that so great a mass of water should burst forth, as to account for the difference between the ebb and flow; and that this should be done so quickly, namely, twice a day; as if the earth, according to that foolish conceit of Apollonius, were taking respiration, and breathing out water every six hours and then taking it in again; is a very great difficulty. And let no one be influenced by the trifling experiment, that some wells in some places are said to have a correspondence with the ebb and flow of the sea; whence one might suspect that the waters inclosed in the cavities of the

earth boil up in a like manner; in which case the swelling could not be well referred to the progressive motion of the waters. For the answer is easy, that the coming in of the tide may close up and fill many hollows and loose places of the earth, turn the subterraneous waters, and beat back the inclosed air; which in a continued succession may raise up the waters of such wells by simple protrusion. Therefore this does not happen in all wells, nor indeed in many; which should be the case if it were the nature of the universal mass of waters to rise and fall by turns, and to correspond with the tide of the sea. But on the contrary, it is so extraordinary as almost to be regarded as a miracle; because (no doubt) such openings and passages extending from wells to the sea are very seldom found without some stoppage or impediment. And it is not out of the way to mention what some say, that in deep mines near the sea the air becomes so thick on the flow of the tide as to threaten suffocation; from which it would appear not that the waters boil up (there being none seen), but that the air is driven back. But indeed there is another experiment which is not to be despised, but is of great weight, and by all means deserves an answer; namely, that it has been found by careful observation (not accidentally noticed, but purposely inquired and discovered) that the tide ebbs on the opposite coasts of Europe and Florida at the same time, and that it does not leave the coast of Europe when it moves to that of Florida, like water stirred in a basin (which I spoke of before), but that it plainly rises and falls on both coasts at the same time. But the solution of this objection will clearly appear in the observations I shall make presently on the course

and progression of the ocean. Now the sum of the matter is this, that the waters which set out from the Indian Ocean, being obstructed by the opposition of the old and new worlds, are driven through the Atlantic from south to north; so no wonder that they approach equally at the same time to both shores, as waters use to do which are driven by the sea into the mouths and channels of rivers, wherein it is most evident that the motion of the sea is progressive with respect to the river, and yet overflows the opposite shores both at the same time. This however I candidly admit, as my manner is, and I would have men attend and remember it; if on experience it be found that it is high water on the coasts of Peru and China at the same time as on the above-mentioned coasts of Europe and Florida, my opinion that the ebb and flow of the sea is a progressive motion must be given up. For if it be high water at the same time on the opposite shores both of the Southern ocean and the Atlantic, there are no other shores left in the world where there can be at the same time a corresponding ebb. But on the result of an appeal to experience (to which I have submitted the cause) in this matter, I feel tolerably secure. For I am plainly of opinion that, if we knew how the case stands all over the world, we should find that the arrangement is fair enough, and that there is at any given hour an ebb in some parts of the globe equal to the flow in others. Wherefore, from what has been said, let this motion of ebb and flow be set down as a progressive motion.

Next comes the inquiry, from what cause, and by what correspondence of things this motion of the ebb

and flow arises and exhibits itself? For all the greater motions (if they be likewise regular and constant) are not solitary or (to use an astronomical term) *ferine*, but have in the nature of things some with which they correspond. And therefore these motions — both the half-monthly motion of increase and the monthly motion of restoration — appear to correspond with the motion of the moon; the half-yearly[1] or equinoctial motion, with that of the sun; and likewise the risings and fallings of the waters with the apogees and perigees of the heavenly bodies. Yet it will not immediately follow (and we would have men observe this) that things which correspond in the course and periods of time, or even in the manner of carriage, are in their nature subordinate, and the cause one of the other. For I do not go so far as to assert that the motions of the moon or sun are set down as the causes of the inferior motions which are analogous to them, or that the sun and moon (as is commonly said) have dominion over those motions of the sea (though such thoughts easily find entrance into men's minds by reason of their veneration for the heavenly bodies); indeed in that very half-monthly motion (if rightly observed) it would be a very strange and novel kind of obedience, for the tides at the new and full moon to be affected in the same way, while the moon is affected in opposite ways; and many other things might be adduced which would destroy these fancies about dominations, and lead us rather to conclude that these correspondences arise out of the universal passions of matter, and the primary combinations of things, not as if one were governed by the other, but that both emanate from the

[1] *Semimenstruus* in the original ought apparently to be *semestris*. — J. S.

same origins and fellow causes. Nevertheless (however it be) what I have said remains true, that nature delights in correspondences, and scarce admits anything unique or solitary. We must see therefore with respect to the six hours' motion of the ebb and flow of the sea, with what other motions it is found to agree and correspond. And first, we must inquire respecting the moon, how this motion sorts and combines with the moon. Now we do not find that there is any resemblance, except in the case of the monthly restoration; for the six-hourly course (whereof I am now inquiring) has no agreement with the monthly; nor again is the flow of the sea found to follow any of the conditions of the moon. For whether the moon be in her increase or wane, whether under the earth or above it, whether elevated high or low above the horizon, or whether situated in the meridian or elsewhere, in none of these instances has the ebb and flow of the sea any correspondence.

Therefore dismissing the moon let us inquire of other correspondences. Now of all celestial motions the diurnal is plainly the shortest, and accomplished in the least time (namely, in the space of twenty-four hours). It is natural therefore to refer this motion whereof we are inquiring (which is still shorter than the diurnal motion by three fourths) to that motion among the celestial bodies which is shortest; but this does not press the matter. What weighs more with me, is that this motion is so distributed as to correspond to the divisions of the diurnal motion; so that although the motion of the waters is almost infinitely slower than the diurnal motion, it is yet commensurable with it. For six hours is a quarter of the diurnal

motion, and six hours is (as I have said) the time of this motion of the sea, with a difference coinciding with the measure of the moon's motion. Of this therefore I am fully persuaded, and take it almost for an oracle, that this motion is of the same kind as the diurnal motion. Taking therefore this as a foundation, I shall proceed to inquire of the rest; and I judge that the whole matter may be resolved by three inquiries. First, does this diurnal motion confine itself to the limits of the heaven, or does it descend and reach lower bodies? Secondly, do the seas move regularly from east to west as the heavens do? Thirdly, whence and in what manner proceeds the reciprocation of the tides every six hours, coinciding with a fourth part of the diurnal motion, though with a difference coinciding with the motion of the moon? With regard to the first inquiry, I judge that the motion of rotation or conversion from east to west is not properly a celestial but quite a cosmical motion; a motion primarily belonging to the great fluids, and found from the summits of heaven to the depths of the water; the inclination being always the same, though the degrees of velocity vary greatly; varying, however, in a regular order, so that the swiftness of the motion diminishes the nearer the bodies approach the earth. Now in the first place that this motion is not terminated with the heaven, may be probably inferred from the fact that it prevails in full vigour through such an immense depth of heaven as that which lies between the starry heaven and the moon (a space much larger than that between the moon and the earth), decreasing regularly all the way; whence it is not likely that nature should throw off suddenly and at once a correspondence of this kind,

which has been continued with a gradual abatement for such an immense distance. That this is the case in celestial bodies is proved by two inconveniences which would otherwise follow. For as it is manifest to the sense that the planets perform a diurnal motion, we must necessarily, unless this motion be set down as natural and proper to all planets, take refuge either in the violence of the *primum mobile*, which is directly contrary to nature, or in the rotation of the earth, — a supposition arbitrary enough, as far as physical reasons are concerned. In the heavens therefore the thing is so. And leaving the heavens, this motion is further seen most plainly in the lower comets, which, though they are lower than the moon, yet evidently revolve from east to west. For though they have their own solitary and irregular motions, yet in the performance thereof they still participate in the motion of the ether, and move in the same direction. They do not commonly keep within the tropics, and have no regular spirals, but run out sometimes towards the poles; but nevertheless they revolve in order from east to west. And this motion of theirs, though greatly diminished (since the nearer they approach to the earth the smaller are the circles in which they revolve, and the slower is the motion), still remains vigorous, so that it can overcome great distances in a short time. For these comets move round the whole circumference both of the earth and the lower air in the space of about four and twenty hours, with one or two hours over. But when descending gradually we come to those regions on which the earth acts not only by a communication of its nature and virtue (which checks and quiets the circular motion), but likewise by a

material infusion of the particles of its substance in thick vapours and exhalations, this motion is immensely deadened and almost collapses; and yet it is not thereby completely exhausted and stopped, but remains in a languid and as it were latent state. For it is now acknowledged that in sailing within the tropics, where from the openness of the sea the motion of the air is best perceived, and where the air itself (like the heaven) revolves in larger circles and therefore with greater velocity, there is found a constant and perpetual breeze blowing from east to west; so that they who want a west wind often seek for it and find it without the tropics.[1] It appears therefore that this motion is not extinguished even in the lowest air; only it now becomes sluggish and feeble; so that it is scarce felt without the tropics. And yet even outside the tropics here in Europe, when the sky is calm and clear, there is observed at sea a certain breeze following the sun, which is of the same kind. And we may also suspect that what we experience here in Europe, where the east wind is keen and drying, whereas on the other hand the west is genial and moist, does not only depend on this — that with us the former blows from the land, the latter from the sea; but likewise on this, that the east wind, being in the same direction as the proper motion of the air, stimulates and irritates that motion, and thereby dissipates and rarefies the air. The west wind, on the other hand, blowing contrary to the motion of the air, turns the air back upon itself, and thereby thickens it. Neither is that common observation to be despised, that the higher clouds generally move from east to west when contrary winds

[1] Acosta, Hist. des Indes, iii. 4.

are at the same time blowing on the earth. And if this is not always the case, the reason is that there are sometimes contrary winds blowing, some above and others below; and those that blow above (if they be opposite) disturb the proper motion of the air. And therefore that this motion is not confined within the limits of the heaven is sufficiently clear.

Next in order is the second inquiry; namely, whether the waters move regularly and naturally from east to west? meaning by waters those collections or masses of water, which form portions of nature large enough to have a correspondence with the fabric and structure of the universe. And I am clearly of opinion that the same motion belongs to this mass of waters and exists in it, but that it is slower than in the air, though by reason of the grossness of the body it is more visible and apparent. Out of many experiments therefore which might be brought to prove this, I shall for the present content myself with three, but those ample and eminent, which demonstrate that this is the fact. The first is that there is found a manifest motion and flow of waters from the Indian Ocean to the Atlantic, and that swifter and stronger towards the Straits of Magellan, where there is an outlet to the west; and also a great motion in the opposite part of the world from the German Ocean into the British Channel. And these courses of water manifestly revolve from east to west. Wherein it is to be especially observed, that in these two places only the seas are open and can perform a complete circle; whereas on the contrary in the middle regions of the world they are cut off by the two obstacles of the Old and New World, and

driven (as into the mouths of rivers) into the two channels of the Atlantic and Southern Ocean, which stretch from north to south, and therefore do not interfere with the order of motion from east to west. The true motion therefore of the waters is most properly taken from these extremities of the world which I have mentioned, where they are not obstructed, but pass through. This is the first experiment. The second is as follows: —

Supposing that the tide at the mouth of the Straits of Gibraltar comes in at a certain hour, it is plain that it must come in later at Cape St. Vincent than at the Straits; later at Cape Finisterre than at Cape St. Vincent; later at Ile de Ré than at Cape Finisterre; later at Noirmoutier (insulam Hechas) than at Ile de Ré; later at the mouth of the English Channel than at Noirmoutier; later on the coast of Normandy than at the entrance of the Channel. And so far it is regular; but at Gravelines the order is completely changed (and that with a great leap), the tide coming in at the same time as at the mouth of the Straits of Gibraltar. And this second experiment I refer to the first. For I conceive (as I before said) that in the Indian and Northern Oceans the proper course of the water from east to west is open and perfect; whereas in the channels of the Atlantic and South Sea it is straitened, thwarted, and repelled by the opposition of land, which on both sides stretches along from north to south, and gives no free outlet to the waters, except towards the extremities. But this compulsion of the waters from the Indian Sea to the north, and that from the German Ocean to the south, differ immensely in extent by reason of the different force and quantity of

the waters. And hence all the Atlantic Ocean as far as the British Channel yields to the force of the Indian Ocean; while only the upper part, namely that which lies towards Denmark and Norway, yields to that of the North Sea. Now this must be so. For the two great islands of the Old and New World are by shape and position broad at the north and pointed at the south; so that the seas towards the south occupy a large space, but the seas towards the north (at the back of Europe, Asia, and America) a small one. Therefore this great mass of waters, which comes from the Indian Ocean and is driven back into the Atlantic, is able to force and push on the course of the waters by a continued succession towards the British Channel, which is a succession towards the north. But that far smaller portion of waters which comes from the North Sea, and has likewise almost a free outlet in its own course towards the west at the back of America, cannot drive the course of the waters towards the south except at the point I have mentioned, about the British Channel. Now it needs must be that between these opposite motions there is some point where they meet in conflict, and where the order of the coming in of the tide is at once changed; as we said happened about Gravelines, which is the point where the currents of the Indian and Northern Sea meet. And that there is a kind of eddy from the contrary tides about Holland has been observed by many, not only from the inversion of the order of the hours of high water (which I have mentioned), but likewise from particular and visible experiment. But if this be so, it returns to this; that it must needs be that the further the parts and coasts of the Atlantic stretch southward

and approach the Indian Ocean, the earlier does the flow of the tide become in point of precedence, inasmuch as it arises from the proper motion of the Indian Sea; but the further they reach to the north (up to the common point, where they are repelled by the contrary stream of the Northern Sea), the later in subsequence. But that this is so, that experiment of the progression from the Straits of Gibraltar to the British Channel plainly shows. Wherefore I judge likewise that it is high water earlier about the coast of Africa than about the Straits of Gibraltar; and reversing the order, that it is earlier about Norway than about Sweden; but this I have not ascertained by experiment or history. The third experiment is as follows: —

Seas shut in on one side, which are called bays, if they tend in their direction from east to west, which is in correspondence with the proper motion of the waters, have vigorous and strong tides; but if they tend in a contrary direction, weak and imperceptible ones. For the Red Sea has a very strong tide; and the Persian Gulf, which runs more directly to the west, a still stronger. But the Mediterranean, which is the largest bay in the world, with its parts the Gulfs of Lyons and Genoa, the Black Sea, and the Sea of Marmora, and likewise the Baltic, which all turn to the east, have hardly any, or weak ones. But this difference is best displayed in the parts of the Mediterranean, which as long as they point to the east or bend to the north (like those I mentioned before) are quiet and without much tide. But when they turn to the west, like the Adriatic, they acquire a notable flow. To which add, that in the Mediterranean what little

ebb there is begins from the ocean, whereas the flow begins from the opposite side, so that the water rather follows its course from the east than the pouring back of the ocean. These three experiments then are all I shall at present use with reference to the second inquiry.

Yet I may add a kind of proof agreeable to the things already spoken, but of an abstruser nature; namely, an argument in favour of this motion from east to west (which I have attributed to the waters), drawn not only from the correspondence of the heavens (whereof I have already spoken) where this motion is in special power and vigour, but likewise from the earth, where it seems forthwith to cease; so that this tendency or motion is truly cosmical, and penetrates everything from the heights of heaven to the depths of the earth. For I understand this rotation from east to west to take place (as it is really found to do) about the north and south poles. Now the diligence of Gilbert has discovered for us most truly that all earth and every nature (which we call terrestrial) that is not supple but rigid, and as he himself calls it robust, has a direction or verticity, latent indeed and yet revealing itself in many exquisite experiments, towards north and south. Which observation I nevertheless limit and correct, by confining the assertion to the exterior concretions about the surface of the earth, and not extending it to the interior (for that the earth is a magnet was a notion hastily taken up from a very light fancy; as it is impossible that things in the interior of the earth can be like any substance exposed to the eye of man; for with us all things are relaxed, wrought upon, and softened by the

sun and heavenly bodies, so that they cannot correspond with things situated in a place where such a power does not penetrate); but the point with which we are now concerned is that the upper incrustations or concretions of the earth appear to correspond with the rotations of the heaven, air, and water, as far as consistent and determinate bodies can correspond with liquids and fluids; that is, not that they revolve upon poles, but that they direct and turn themselves towards poles. For as every revolving orb which turns on fixed poles and has no central motion partakes in a way of both a movable and a fixed nature, so when by the solid or self-determining nature of the body the power of revolving is bound up, the power and desire of self-direction still remains and is increased and united; so that the direction and verticity towards the poles in rigid bodies is the same thing as revolving upon the poles in fluid.

There remains the third inquiry; whence and in what manner is that six-hourly reciprocation of the tides produced, which coincides with a quarter of the diurnal motion, with the above-mentioned difference? To understand this, suppose the whole world to be covered with water, as at the deluge. I conceive that the waters, being now in a perfect orb, and no way obstructed, would continually move every day a certain distance from east to west (not a great one indeed, by reason of the wearing out and weakening of this motion in the confines of the earth), since they would be nowhere obstructed or checked by the opposition of land. Suppose, again, the earth to be a single island, stretching out lengthways from north to south, that

being the shape and position which most checks and obstructs the motion from east to west; I conceive that the waters would hold on in their straight and natural course for a time, but that afterwards, being driven back by that island, they would return in equal intervals; so that there would only be one flow and one ebb in the course of the day, and about twelve hours would be given to each of them. And now suppose (what is indeed the fact) the earth to be divided into two islands, namely, the Old and New World (for the southern continent from its position does not make much difference, as neither do Greenland or Nova Zembla), and these two islands to extend almost through three zones, between which the two oceans, the Atlantic and Southern, flow, but have no passage through except towards the poles; I conceive it must needs follow that these two obstacles will infuse and communicate the nature of a twofold reciprocation to the whole body of the water, and thence comes that quarter of the diurnal motion; for that the waters being checked on both sides, the ebb and flow of the sea must come twice a day, every six hours, there being a double advance and likewise a double repercussion. And if these two islands were extended in the waters like cylinders or columns, with equal dimensions and straight shores, this motion, which now seems confused and obscured by reason of the variety of position in sea and land, would be easily demonstrated, and would suggest itself to anybody. Neither likewise is it difficult to form some conjecture of the degree of velocity that may be reasonably assigned to this motion of the waters, and of the distance it performs in one day. For if (to estimate this) you take some of those shores which are

least mountainous or depressed, and are contiguous to an open sea, and if you take a measure of the distance between high and low water mark, and if you multiply this distance by four on account of the four tides a day, and again double the product on account of the tides at the opposite shores of the same sea, and add something more on account of the height of coasts, which are always somewhat raised above the level of the sea; this calculation will give the distance which a globe of water, if it were free from all obstruction and always moved in a circular progression round the earth, would travel; and certainly it is not a great one. Now with respect to that difference which coincides with the moon's motion, and makes the period a month; I conceive it to be due to this: that the time of six hours is not the exact measure of reciprocation, as neither is the diurnal motion of any of the planets restored exactly in twenty-four hours; and that of the moon least of all. Therefore the measure of the ebb and flow of the sea is not a quarter of the motion of the fixed stars, which is the motion of twenty-four hours, but a quarter of the diurnal motion of the moon.

Injunctions.

Inquire whether the time of high water about the coast of Africa precedes that about the Straits of Gibraltar. Inquire whether the time of high water about Norway precedes that of high water about Sweden; and in like manner whether the latter precedes that about Gravelines.

Inquire whether the time of high water on the coast of Brazil precedes the time of high water on the coasts of New Spain and Florida.

Inquire whether the time of high water on the coast of China is not the same, or very nearly the same, as the time of high water on the coast of Peru; and also as the time of low water on the coasts of Africa and Florida.

Inquire how the time of high water on the coast of Peru differs from that of high water on the coast of New Spain, and particularly of the differences in the hours of high water on the two shores of the Isthmus of Darien; and again how the time of high water on the coast of Peru corresponds to the time of high water on the coast of China.

Inquire of the heights of the tides on different coasts, as well as of their times and hours. For though high tides are mostly caused by depressions of coasts, yet they have some relation likewise to the true motion of the sea, according as it is with them or against them.

Inquire of the Caspian Sea (which is a large land-locked collection of waters, with no outlet to the ocean) to see if it has any ebb and flow, or of what nature it is; for my own conjecture is, that the waters of the Caspian may have one tide a day, but not two; and such that there shall be low water on the eastern coasts of that sea, when there is high water on the western.

Inquire whether the higher flood tides at the new and full moon, and likewise at the equinoxes, take place in different parts of the world at the same time; and when I say *at the same time*, I do not mean the same hour (for the hours vary, as I have said, according to the progression of the waters along the shore), but the same day.

Limitations.

The inquiry is not carried out to a full explanation of the correspondence of the monthly motion of the sea with the motion of the moon; as to whether it be the effect of subordination, or of a common cause.

Connections.

The present inquiry is connected with the inquiry whether the earth has a diurnal motion. For if the tide be, as it were, the extreme diminution of the diurnal motion, it will follow that the globe of the earth is immovable, or at least that it moves much slower than the waters themselves.

ON

PRINCIPLES AND ORIGINS,

ACCORDING TO THE FABLES OF

CUPID AND CŒLUM:

ETC.

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THE stories told by the ancients concerning Cupid, or Love, cannot all apply to the same person; and indeed they themselves make mention of two Cupids, very widely differing from one another; one being said to be the oldest, the other the youngest of the gods. It is of the elder that I am now going to speak. They say then that this Love was the most ancient of all the gods, and therefore of all things else, except Chaos, which they hold to be coeval with him. He is without any parent of his own; but himself united with Chaos begat the gods and all things. By some however it is reported that he came of an egg that was laid by Nox. Various attributes are assigned to him: as that he is always an infant, blind, naked, winged, and an archer. But his principal and peculiar power is exercised in uniting bodies; the keys likewise of the air, earth, and sea were entrusted to him. Another younger Cupid, the son of Venus, is also spoken of, to whom the attributes of the elder are transferred, and many added of his own.

This fable, with the following one respecting Cœlum, seems to set forth in the small compass of a parable a doctrine concerning the principles of things and the origins of the world, not differing in much from the philosophy which Democritus held, excepting that it appears to be somewhat more severe, sober, and pure. For the speculations of that philosopher, acute and diligent as he was, could not rest nor keep within bounds, nor put a sufficient check and control over themselves. And even the opinions which are veiled in the parable, though somewhat more correct, are yet no better than such as proceed from the intellect left to itself and not resting constantly on experience and advancing step by step; a fault to which I suppose the primitive ages were likewise subject. It must be understood however in the first place, that the things here brought forward are drawn and concluded from the authority of human reason alone, according to the belief of the sense, whose expiring and failing oracles are deservedly rejected since a better and more certain light has been shed upon us from divine revelation. This Chaos then, which was contemporary with Cupid, signified the rude mass or congregation of matter. But matter itself, and the force and nature thereof, the principles of things in short, were shadowed in Cupid himself. He is introduced without a parent, that is to say, without a cause; for the cause is as the parent of the effect; and it is a familiar and almost continual figure of speech to denote cause and effect as parent and child. Now of this primary matter and the proper virtue and action thereof there can be no cause in nature (for we always except God), for nothing was before it. Therefore there was no efficient cause of

it, nor anything more original in nature; consequently neither genus nor form. Wherefore whatsoever this matter and its power and operation be, it is a thing positive and inexplicable, and must be taken absolutely as it is found, and not to be judged by any previous conception. For if the manner could be known, yet it cannot be known by cause, seeing that next to God it is the cause of causes, itself only without a cause. For there is a true and certain limit of causes in nature; and it is as unskilful and superficial a part to require or imagine a cause when we come to the ultimate force and positive law of nature, as not to look for a cause in things subordinate. And hence Cupid is represented by the ancient sages in the parable as without a parent, that is to say, without a cause, — an observation of no small significance; nay, I know not whether it be not the greatest thing of all. For nothing has corrupted philosophy so much as this seeking after the parents of Cupid; that is, that philosophers have not taken the principles of things as they are found in nature, and accepted them as a positive doctrine, resting on the faith of experience; but they have rather deduced them from the laws of disputation, the petty conclusions of logic and mathematics, common motions, and such wanderings of the mind beyond the limits of nature. Therefore a philosopher should be continually reminding himself that Cupid has no parents, lest his understanding turn aside to unrealities; because the human mind runs off in these universal conceptions, abuses both itself and the nature of things, and struggling towards that which is far off, falls back on that which is close at hand. For since the mind, by reason of its narrowness, is commonly most moved by things

of familiar occurrence and which may enter and strike it directly and at once, it comes to pass that when it has advanced to those things which are most universal in experience, and yet cannot be content to rest in them, that then, as if striving after things still more original, it turns to those by which itself has been most affected or ensnared, and fancies these to be more causative and demonstrative than those universals themselves.

It has been said then that the primitive essence, force and desire of things has no cause. How it proceeded, having no cause, is now to be considered. Now the manner is itself also very obscure: and of this we are warned by the parable, where Cupid is elegantly feigned to come of an egg which was laid by Nox. Certainly the divine philosopher declares that "God hath made everything beautiful in its season, also he hath given the world to their disputes; yet so that man cannot find out the work that God worketh from the beginning to the end."[1] For the summary law of being and nature, which penetrates and runs through the vicissitudes of things (the same which is described in the phrase, "the work which God worketh from the beginning to the end"), that is, the force implanted by God in these first particles, from the multiplication whereof all the variety of things proceeds and is made up, is a thing which the thoughts of man may offer at but can hardly take in. Now that point concerning the egg of Nox bears a most apt reference to the demonstrations by which this Cupid is brought to light. For things concluded by affirmatives may be considered as the offspring of light;

[1] Eccles. iii. 11.

whereas those concluded by negatives and exclusions are extorted and educed as it were out of darkness and night. Now this Cupid is truly an egg hatched by Nox; for all the knowledge of him which is to be had proceeds by exclusions and negatives: and proof made by exclusion is a kind of ignorance, and as it were night, with regard to the thing included. Whence Democritus excellently affirmed that atoms or seeds, and the virtue thereof, were unlike anything that could fall under the senses; but distinguished them as being of a perfectly dark and hidden nature; saying of themselves, "that they resembled neither fire nor anything else that could be felt or touched;"[1] and of their virtue, "that in the generation of things the first beginnings must needs have a dark and hidden nature, lest something should rise up to resist and oppose them."[2] Atoms therefore are neither like sparks of fire, nor drops of water, nor bubbles of air, nor grains of dust, nor particles of spirit or ether. Neither is their power and form heavy or light, hot or cold, dense or rare, hard or soft, such as those qualities appear in greater bodies; since these and others of the kind are results of composition and combination. And in like manner the natural motion of the atom is not that motion of descent which is called natural, nor the one contrary to it (that of percussion), nor the motion of expansion and contraction, nor the motion of impulse

[1] Lucret. i. 688.: —

Neque sunt igni simulata, neque ulli
Præterea rei quæ corpora mittere possit
Sensibus, et nostros adjectu tangere tactus.

[2] Id. i. 779.: —

At primordia gignundis in rebus oportet
Naturam clandestinam cæcamque adhibere,
Emineat ne quid, quod contra pugnet et obstet.

and connection, nor the motion of rotation of the celestial bodies, nor any of the other motions of large bodies simply. Notwithstanding in the body of the atom are the elements of all bodies, and in the motion and virtue of the atom are the beginnings of all motions and virtues. But yet on this point, namely, the motion of the atom compared with the motion of larger bodies, the philosophy of the parable seems to differ from that of Democritus. For Democritus is found to be not only at variance with the parable, but inconsistent and almost in contradiction with himself in that which he says further on this point. For he should have attributed to the atom a heterogeneous motion, as well as a heterogeneous body and a heterogeneous virtue; whereas, out of the motions of the larger bodies, he has selected two motions; namely, the descent of heavy things and the ascent of light (which latter he explained as the effect of force or percussion of the heavier driving the less heavy upwards), and ascribed them as primitive motions to the atom. The parable on the contrary preserves the heterogeneity and exclusion throughout, both in substance and motion. But it further intimates, that there is some end and limit to these exclusions; for Nox does not sit for ever. And certainly it is the prerogative of God alone, that when his nature is inquired of by the sense, exclusions shall not end in affirmations. But here the case is different; and the result is, that after due exclusions and negations something is affirmed and determined, and an egg laid, as it were, after a proper course of incubation; and not only that Nox lays her egg, but that from this egg is hatched the person of Cupid: that is to say, not only is some notion of the thing

educed and extracted out of ignorance, but a distinct and definite notion. With regard then to the kind of demonstrations which are possible concerning primary matter, this is what I conceive to be most in accordance with the meaning of the parable. Let us now proceed to Cupid himself, that is, primary matter, together with its properties, which are surrounded by so dark a night; and see what light the parable throws upon this. Now I am well aware that opinions of this kind sound harsh and almost incredible to the senses and thoughts of men. As we see it has been tried and proved in this very philosophy of Democritus respecting atoms, which, because it penetrated somewhat more sharply and deeply into nature and was further removed from common ideas, was treated as childish by the vulgar; and was moreover by the disputes of other philosophies more adapted to their capacity blown about and almost extinguished. And yet this man was much admired in his day,[1] and was called Pentathlus from the variety of his knowledge, and by consent of all was esteemed the greatest physical philosopher, so that he obtained also the surname of Magus. Nor could either the battles and contests of Aristotle (who after the Ottoman fashion felt insecure about his own kingdom of philosophy till he had slain his brethren; and who was likewise anxious, as appears from his own words, that posterity should doubt about nothing), or the majesty and solemnity of Plato, so far prevail — the one by violence, the other by reverence — as to obliterate entirely this philosophy of Democritus. But while that of Plato and Aristotle was noised and celebrated in the schools amid the din

[1] Diog. Laert. ix. 37.

and pomp of professors, this of Democritus was held in great honour with the wiser sort, and those who embraced more closely the more silent and arduous kinds of speculation. Certainly in the times of Roman learning that of Democritus was not only extant but well accepted; for Cicero mentions him everywhere in terms of the highest praise; and the well-known lines of the poet, who appears to have spoken (as poets commonly do) according to the judgment of his own time, were written not long after; wherein he is quoted as an instance to prove that great men may be born in heavy climates.[1] Therefore it was not Aristotle or Plato, but Genseric and Attila and the barbarians, who destroyed this philosophy. For at that time, when all human learning had suffered shipwreck, these planks of Aristotelian and Platonic philosophy, as being of a lighter and more inflated substance, were preserved and came down to us, while the more solid parts sank and almost passed into oblivion. But to me the philosophy of Democritus seems worthy to be rescued from neglect; especially as in most things it agrees with the authority of the earliest ages. First therefore Cupid is described as a person; and to him are attributed infancy, wings, arrows, and other things of which I will afterwards speak separately. But in the mean time I make this assumption; that the ancients set down the first matter (such as may be the beginning of things) as having form and qualities, not as abstract, potential, and unshapen. And certainly that despoiled and passive matter seems altogether a

[1] Juv. x. 48.: —

Cujus prudentia monstrat,
Magnos posse viros, et magna exempla daturos,
Vervecum in patria crassoque sub aere nasci.

fiction of the human mind, arising from this, that to the human mind those things most seem to exist, which itself imbibes most readily, and by which it is most affected. It follows therefore that forms (as they call them) seem to exist more than either matter or action; because the former is hidden, the latter variable; the former does not strike so strongly, the latter does not rest so constantly. These images on the other hand are thought to be both manifest and constant; so that the first and common matter seems to be as an accessory and support; and action, of whatever kind, to be merely an emanation from the form; and altogether the first place is assigned to forms. And hence appears to have come the reign of forms and ideas in essences; with the addition (that is to say) of a kind of fantastical matter. All which was increased, moreover, by superstition (intemperance following error); and abstract ideas and their dignities were also introduced, with so much confidence and majesty, that the dreamers almost overpowered the wakers. These things however have now for the most part vanished; though an individual in our age has tried, with more boldness (as it appears to me) than success, to prop them up in their decline and resuscitate them. But how contrary to reason it is to lay down abstract matter as a principle is easily seen, if prejudices be not in the way. For the actual existence of separate forms has been asserted by some, of separate matter by no one; not even by those who have taken it for a principle; and to constitute entities from things imaginary seems hard and perverse, and not consonant with the inquiry concerning principles. For the inquiry is not how we may most conveniently embrace and distinguish the

nature of entities in our thoughts, but what are really the first and most simple entities from which the rest are derived. Now, the first entity must exist no less really than the things derived from it; and in a certain way more. For it is self-subsisting, and other things subsist by it. But the things which are said about this abstract matter are not much better than if a man were to assert that the world and all things are made of categories and such like logical notions, as principles. For it makes little difference whether you say that the world is made of matter, form, and privation, or of substance and contrary qualities. But almost all the ancients, as Empedocles, Anaxagoras, Anaximenes, Heraclitus, and Democritus, though in other respects they differed about the first matter, agreed in this, that they set down matter as active, as having some form, as dispensing that form, and as having the principle of motion in itself. Nor can any one think otherwise, unless he plainly deserts experience. Therefore all these submitted their minds to the nature of things. Whereas Plato made over the world to thoughts; and Aristotle made over thoughts to words; men's studies even then tending to dispute and discourse, and forsaking the stricter inquiry of truth. Hence such opinions are rather to be condemned in the whole, than confuted separately in the parts; for they are the opinions of those who wish to talk much, and know little. And this abstract matter is the matter of disputation, not of the universe. But one who philosophises rightly and in order, should dissect nature and not abstract her (but they who will not dissect are obliged to abstract); and must by all means consider the first matter as united to the first

form, and likewise to the first principle of motion, as it is found. For the abstraction of motion also has begotten an infinite number of fancies about souls, lives, and the like; as if these were not satisfied by matter and form, but depended on principles of their own. But these three are by no means to be separated, only distinguished; and matter (whatever it is) must be held to be so adorned, furnished, and formed, that all virtue, essence, action, and natural motion, may be the consequence and emanation thereof. Nor need we fear that the result will be general torpor, or that the variety of things which we see cannot be explained; as I will show hereafter. Now that the first matter has some form is demonstrated in the fable by making Cupid a person: yet so that matter as a whole, or the mass of matter, was once without form; for Chaos is without form; Cupid is a person. And this agrees well with Holy Writ; for it is not written that God in the beginning created matter, but that he created the heaven and the earth.

There is subjoined likewise some description of the state of things as it was before the work of the six days, wherein distinct mention is made of earth and water, which are the names of forms; but yet in the whole the mass was still unformed. But though Cupid is represented in the allegory as a person, he is yet naked. Therefore, next to those who make matter abstract, they are most in error (though on the contrary side) who make it clothed. I have slightly touched on this in what has been already said of the demonstrations applicable to the first matter, and of the heterogeneous nature of matter itself. But this part on which I am now entering is the proper place for treat-

ing of them. We must see therefore among those who have grounded the principles of things in formed matter, who they are who have attributed a native and naked form to matter, and who one apparelled and clothed. Now, in all there are four different opinions on this. The first is that of those who assert that there is some one principle of things, but make the diversity of beings to consist in the inconstant and dispensable nature of that same principle. The second is that of those who make the principle of things one in substance, and that fixed and invariable; but deduce the diversity of beings from the different magnitudes, configurations, and positions of that same principle. The third is that of those who set up many principles of things, and lay the diversity of beings to the tempering and mixing of them. The fourth is that of those who constitute infinite, or at least numerous, principles, but make them specific and formed; and these have no need of any device to account for the multiplicity of things; for they diversify nature at the very outset. Of these sects the second alone appears to me to represent Cupid as he is — native and naked. For the first introduces him as separated by a veil, the third as wearing a tunic, and the fourth as cloaked and almost masked. But on each of these I will speak a few words, for the better explanation of the allegory. First therefore among those who have asserted one principle of things, I have found no one who would affirm that principle to be the earth. For the quiet, sluggish, and inactive nature of the earth which submits patiently to the heaven, fire, and other things, prevented such an assertion from entering into any one's mind. Nevertheless the wisdom of the ancients

made Earth to come next to Chaos, and to be first the parent, then the bride of Cœlum, from which marriage all things were born. But it is not to be therefore understood that the ancients ever constituted the earth the principle of essence; but only the principle, or rather origin, of configuration or system. I refer this point therefore to the following allegory respecting Cœlum, when I shall inquire about origins; which inquiry is posterior to that of principles.

Thales asserted Water to be the principle of things.[1] For he saw that matter was principally dispensed in moisture, and moisture in water; and it seemed proper to make that the principle of things, in which the virtues and powers of beings, and especially the elements of their generations and restorations, were chiefly found. He saw that the breeding of animals is in moisture; that the seeds and kernels of plants (as long as they are productive and fresh), are likewise soft and tender; that metals also melt and become fluid, and are as it were concrete juices of the earth, or rather a kind of mineral waters; that the earth itself is fertilised and revived by showers or irrigation, and that earth and mud seem nothing else than the lees and sediment of water; that air most plainly is but the exhalation and expansion of water; nay, that even fire itself cannot be lighted, nor kept in and fed, except with moisture and by means of moisture. He saw too, that the fatness which belongs to moisture, and which is the support and life of flame and fire, seems a kind of ripeness and concoction of the water. Again, that the body and bulk of water is distributed throughout the universe, as the common support of everything; that

[1] Plut. de Plac. Philosoph. i. 3.

the earth is encircled by the ocean; that there is a vast supply of fresh water within the earth, whence come springs and rivers, which like the veins of a body, carry off water over the surface and through the bowels of the earth. That there are also immense masses and collections of vapours and waters in the upper regions; — another universe of waters, as it were, for the repair and refreshment of those below, and indeed of the ocean itself. He also supposed that even the celestial fires fed on these vapours and waters, inasmuch as they could neither subsist without aliment nor be nourished by anything else; also that the configuration of water, as seen in its particles (I mean drops), is the same as the configuration of the universe, namely, round and spherical; moreover that the undulation of water is seen and observed likewise in air and flame; and lastly, that the motion of water is easy, neither sluggish nor too rapid, and that the generation of fish and water animals is very numerous. But Anaximenes selected Air to be the one principle of things. For if mass is to be regarded in constituting the principles of things, air seems to occupy by far the greatest space in the universe. For unless a separate vacuum be allowed, or the superstition concerning the heterogeneity between celestial and sublunary bodies be received, it would seem that the whole extent of space between the globe of the earth and the bodies of the heaven, — all of it that is not either star or meteor, — is filled with an airy substance. Now the terrestrial globe is but as a point compared with the heaven that surrounds it. But in the ether itself how small a portion is studded with stars? In the spheres next the earth each star is seen singly; and in that

furthest from it, though the number of them is immense, yet they occupy a small space in comparison to the distances between them; so that all things seem to float as it were in a vast sea of air. Nor is it a small portion of air and spirit which resides in waters and in cavities of the earth; whence waters receive their fluidity, and sometimes also spread and swell; and the earth, besides its porosity, has its tremblings and shakings, which are evident signs of confined air and wind. And if a kind of middle nature be suited to principles, as being susceptible of so great a variety, this seems to be found in perfection in the air. For air is as the common link of things, not only because it is everywhere present, and comes in and occupies vacuities, but much rather because it seems to have a middle and indifferent nature. For it is a body which receives and conveys light, opacity, the tints of all colours, and obscurations of shade; which likewise distinguishes with the greatest accuracy the different impressions and notes of musical and (what is greater) articulate sounds; which admits without confusion the differences of smells, not only the general ones of sweet, foul, heavy, brisk, and the like, but also the peculiar and specific, as the smell of a rose or violet; which is indifferently disposed towards the great and powerful qualities of heat, cold, moisture and dryness; in which watery vapours, fat exhalations, spirits of salts and fumes of metals hang and float; lastly, in which the radiations of the heavenly bodies, and the closer agreements and disagreements of things secretly communicate and dispute; so that air is like a second chaos, in which the seeds of so many things act, wander, endeavour, and experiment. Finally if you consult the generative and vivi-

fying power in things as that which may lead us up to principles, and make them manifest; in these likewise air seems to play the principal part; so that the names of air and spirit and life or breath are sometimes confounded. And rightly; since respiration is as it were the inseparable companion of the more advanced states of life, (that is, excepting the first rudiments of life in embryos and eggs); in so much that fish are suffocated when the surface of the water is hard frozen. Even fire itself, unless it be animated by the surrounding air, dies out, and seems to be nothing else than air rubbed together, excited and kindled; as water, on the other hand, seems to be but a congelation and contraction of air. The earth also perpetually exhales air, and has no need to pass through water into the form of air. Heraclitus, on the other hand, with more acuteness but less credibility, made Fire to be the principle of things. For he did not look for a middle nature, which is usually the most vague and corruptible, to constitute the principles of things; but for a consummate and perfect one, such as might be the end and period of corruption and alteration. Now he saw that the greatest variety and confusion was found in solid and consistent bodies. For such bodies may be organic, and like machines, which from their very configuration admit innumerable variations; such as are the bodies of plants and animals. And even those which are not organic, are yet on minute inspection found to be very dissimilar. For how great is the dissimilarity between those parts of animals which are called similar? the brain, the crystalline humour, the white of the eye, bone, membrane, cartilage, nerve, vein, flesh, fat, marrow, blood, seed, spirit, chyle, and the like?

and likewise in the parts of vegetables, the root, bark, stem, leaf, flower, seed, and the like? Fossils certainly are not organic, but yet they exhibit both a great mixture in one species, and a very plentiful variety compared one with another. Wherefore this broad, ample, and extensive basis of the diversity of beings, wherein so large an array of things displays itself and comes into action, seems to consist in the nature of solidity and consistence. But the bodies of liquids are plainly without the power of organic structure. For through the whole world of visible nature there is found no animal or plant in a body simply fluid; and therefore this infinite variety is precluded and cut off from the nature of liquidity. And yet the liquid nature has its variety, and that in no small degree, as is manifested in the great diversity of melted bodies, juices, distilled liquors, and the like. Whereas in airy and pneumatic bodies this variety is much more limited, and a sort of promiscuous resemblance of things takes its place. Certainly that virtue of colours and tastes, whereby liquids are sometimes distinguished, absolutely ceases; that of odours indeed and some other things remains, yet only transitory, confused, and separable: so that as a general rule, the nearer bodies approach to the nature of fire, the more do they lose of variety. And after they have assumed the nature of fire, and that in a rectified and pure state, they throw off every organ, every property, and every dissimilarity; and nature seems as it were to gather to a point in the vertex of the pyramid, and to have reached the limit of her proper action. Therefore this kindling or catching fire Heraclitus called peace; because it composed nature and made her one; but generation he called war, be-

cause it multiplied and made her many.[1] And that this process (by which things flowed and ebbed, like the tide, from variety to unity, and from unity to variety) might be some way explained, he maintained that fire was condensed and rarefied, yet so that its rarefaction towards a fiery nature was the direct and progressive action of nature; while its condensation was a kind of retrograde action or failing of the same. Both of these he considered to take place by fate, and (in the sum of things) at certain periods; so that this revolving world would some time or other be set on fire, and afterwards renewed again, and that this series and succession of conflagration and generation would go on for ever. Only the inflammation and the extinction were according to him (if one studies diligently the scanty account which has come down to us of the man and his opinions) to take place in a different order. For as to the process of inflammation, he no way differed from the common opinions; that the progress of rarefaction and extenuation went on from earth to water, from water to air, from air to fire. But the way back was not by the same stages; the order being directly inverted. For he affirmed that fire by its extinction produces earth, as its dregs and soot; that these then conceive and collect moisture, whence proceeds an overflow of water, which again emits and exhales air; so that the change from fire to earth is sudden, not gradual.

Such then, or better than these, were the opinions of those who laid down one principle of things; regarding nature simply, not contentiously. And they deserve commendation for giving Cupid but one gar-

[1] Diog. Laert. ix. 8.

ment, which is the next degree to nakedness; and that garment too (as I have said) like a veil, and of no thicker texture. Now by the garment of Cupid I mean some form attributed to the primary matter, that may be said to be substantially homogeneous with the form of any of the secondary essences. But the assertions made by them with respect to water, air, and fire, which rest on no very firm grounds, it will not be difficult to confute; nor does there seem to be any reason for discussing them severally, so I will only touch on them in general. First therefore, in the inquiry of principles these ancient philosophers do not appear to have adopted a very perfect system; but what they did was only to seek out among apparent and manifest bodies that which seemed most excellent, and set down that as the principle of all things; by right, as it were, of its excellence; not as being truly and really so. For they thought that such a nature was the only one of which it could be said that it is what it seems; other things they thought were this same nature, though not according to appearance; so that they seem to have spoken either figuratively, or under the influence of fascination; the stronger impression carrying the rest with it. But a true philosopher should look at all things alike, and lay down those as the principles of things, which agree as well with the smallest, rarest, and most neglected of essences, as with the greatest and most numerous and vigorous. For though we men most admire the beings which are most universal, yet the bosom of nature is opened to all. If on the other hand they hold this principle of theirs not by excellence, but simply, they seem certainly to have fallen on a harsh figure of speech; for it

brings it plainly to a matter of equivocation, what they assert not being predicated either of natural fire or natural air or natural water, but of some imaginary and ideal fire, air, &c., which retains the name, but does not answer the definition. They seem further to be driven to the same difficulties in which the assertors of abstract matter are involved; for as those introduce a potential and imaginary matter altogether, so do these likewise in part. Moreover they make matter formed and actual with respect to one thing (namely, that principle of theirs), but potential with respect to everything else. Nor does there seem to be any advantage in this kind of single principle, more than in that of abstract matter; except that it has something to offer to the human understanding, whereon the thoughts of men may better fix themselves and rest, and by which the notion of the principle itself becomes somewhat fuller, though that of all other things more abstruse and hard. But the fact is that at that time the *Predicaments* had not commenced their reign, whereby this principle of an abstract nature might have sheltered itself under the credit and protection of the predicament of substance; and therefore no one durst feign a matter quite imaginary, but asserted a principle according to sense; some true entity; the manner only of dispensation (for in that they used greater license) being imaginary.[1] For they do not discover, nay, do not even speculate, by what appetite or spur, or by what reason, way, or inducement, that principle of theirs degenerates from, and again recovers its nature. But seeing there are such armies of contraries in the world, as of dense and

[1] Cf. Aristot. Met. i. 3.

rare, hot and cold, light and darkness, animate and inanimate, and many others, which oppose, deprive, and destroy one another in turn; to suppose that all these emanate from some one source of a material substance, and yet not to show any manner in which the thing can be, seems but a confused speculation, and an abandonment of inquiry. For if the thing itself were ascertained by the sense, you must receive it, though the manner thereof be hidden; and again, if by force of reason any convenient and credible manner could be discovered, you must perhaps give up appearances; but you should by no means be required to assent to those things whereof neither the being is manifest by the sense, nor the explanation probable by the reason. Besides, if there were but one principle of things, it ought to have a visible mark, and as it were a superiority and predominance in all things; nor should anything of importance be found diametrically opposite to that principle. Likewise it should hold a middle position, so as to be more conveniently available for everything, and diffuse itself around. But there is nothing of this found in the principles of those philosophers. For the earth, which is cut off and excluded from the honour of a principle, seems to receive and cherish natures opposed to those three principal natures; for to the mobility and lucidity of fire it opposes rest and opacity; to the tenuity and softness of air, in like manner, it opposes density and hardness; and to the moistness and sequacity of water, dryness, rigidity, and asperity; besides, the earth itself occupies the central place, the rest being turned out. And further, if there were only one principle of things, it ought to have a nature indifferently disposed towards the gener-

ation and the dissolution of them. For it is as much the condition of a principle that things should resolve themselves into it, as that things should be produced from it. But this is not the case; for of these bodies, air and fire seem unsuited to supply matter for the generation of things, though ready to receive their dissolution; whereas water, on the other hand, is favourable and good for generation, but more unfit and averse to dissolution or restoration; as would be easily seen if for some time there were to be no rain. Moreover, putrefaction itself in no way reduces things to crude and pure water. But by far the greatest error is that they set up for a principle that which is corruptible and mortal; for they do no less when they introduce such a principle as forsakes and lays aside its nature in compositions. "For when a thing shifts and changes, that which it was dies."[1]

But I shall have to make further use of this reason presently, now that our discourse has come down in order to the third sect, which asserted many principles of things; a sect which seems to have more strength on its side and certainly has more prejudice. Therefore I will not examine their opinions in general or in common, but one by one.

Among those who have maintained that there are many principles I shall set aside those who hold them to be infinite; for the point concerning infinity belongs to the allegory respecting Cœlum. But among the ancients Parmenides maintained two principles of things, fire and earth, or heaven and earth. For he asserted

[1] Lucret. iii. 518.:—

Nam quodcunque suis mutatum finibus exit,
Continuo hoc mors est illius, quod fuit ante.

that the sun and stars were real fire, pure and limpid, not degenerate as fire is with us, which is only as Vulcan thrown down from heaven, and lamed by the fall. And these opinions of Parmenides Telesius has in our age revived; a man strong and well armed with the reasonings of the Peripatetics (if they were worth anything), which likewise he has turned against themselves; but embarrassed in his affirmations, and better at pulling down than at building up. Of the discoveries of Parmenides himself the account is very scanty and shadowy; yet the foundations of a similar opinion seem plainly laid in the book written by Plutarch on the "Primal Cold;" which appears to have been derived from some ancient treatise, at that time extant but now lost. For it contains not a few things both more acute and more sound than the speculations of the author himself commonly are, and by these Telesius appears to have been prompted and incited to take them up studiously and follow them out strenuously in his "Commentaries on the Nature of Things." Now the opinions of this sect are as follows: That the first forms, and the first active entities, and therefore the first substances, are heat and cold; yet that these have no body, but a passive and potential matter, which supplies a corporeal bulk, and is equally susceptible of both natures; itself without any action at all. That light is a sprouting of heat, but of heat dissipated, which being multiplied by collection becomes robust and sensible. That darkness in like manner is the destitution and confusion of the radiating nature from cold. That density and rarity are but the textures and, as it were, the webs of heat and cold; heat and cold being the producers and operatives thereof; cold

condensing and thickening the work, heat separating and extending it. That from such textures a disposition towards motion, either apt or averse, is impressed upon bodies; that is, prompt and apt upon rare bodies, sluggish and averse upon dense. Therefore that heat by tenuity excites and creates motion; cold by density checks and quiets it. Hence that there are four coessential and conjugate natures, and those of two kinds, preserving the respective order I have mentioned (for the source is heat and cold, the rest are emanations); but yet always concomitant and inseparable. These are heat, lucidity, rarity, mobility; and again, their four opposites, cold, opacity, density, immobility. That the seats and stages of the first conjugation are placed in the heaven, stars, and especially in the sun; of the second, in the earth. For that the heaven, from its perfect and entire heat and the extreme extension of matter, is most hot, lucid, rarefied, and moveable; whereas the earth, on the contrary, from its entire and unrefracted cold, and the extreme contraction of matter, is most cold, dark, and dense, completely immoveable, and exceedingly averse to motion. That the summits of the heaven preserve their nature entire and inviolate, admitting some diversity among themselves, but completely removed from the violence and insult of a contrary body; that there is a like constancy in the depths or innermost parts of the earth; and that it is only the extremities, where contrary bodies approach and meet together, which struggle and suffer, and are assailed by one another. That the heaven therefore, in its whole bulk and substance, is hot, and quite free from every contrary nature, but that heat is unequal; some parts being more, others

less hot. For that in the body of the stars heat is more intense, in the space between them less so; moreover that of the stars themselves, some are more burning than others, and have a livelier and more radiant fire; yet so that the contrary nature of cold, or any gradation thereof, never penetrates there; for that it admits a difference of nature, but not a contrariety. That you must not however judge of the heat or fire of celestial bodies, which is entire and native, from common fire. For that our fire is out of its place, trembling, surrounded with contrary bodies, needy, dependent for its preservation on the fuel given it, and fugitive; whereas in heaven it is in its true position, apart from the violence of any contrary body, constant, kept up by itself and similar things, and performing its proper operations free and undisturbed. Also that the heaven is bright everywhere, but with differences of more or less. For that, seeing there are among the known and numbered stars some which are only visible in a clear sky, and in the milky way there are knots of small stars which show a kind of whiteness all together, but are not severally distinguishable as bright bodies; no one can doubt but that there are many stars invisible to us; and indeed that the whole heaven is endued with light, though not with a splendour so strong and far-darting, nor with rays so thick and close, as can travel so great a distance and come to our view. So again, that the whole heaven consists of a fine and rare substance, nothing in that substance being crowded or packed closer than it likes, but yet that in some parts matter is more extended, in others less. Lastly, that the motion of the heaven is found to be that which suits the most moveable body: namely,

the motion of conversion or rotation. For circular motion is interminable, and for its own sake. Motion in a straight line is to an end, and for the sake of something, and as it were to obtain rest. Therefore that the whole heaven moves with a circular motion, and no part of it is free from that motion; but yet as in the heat, light, and rarity of heaven there is inequality, the same likewise is observed in its motion; an inequality the more conspicuous because it more invites and bears human observation, and may even be reduced to calculation. Now, orbicular motion may differ both in velocity and direction; in velocity it may be quicker or slower; in direction, it may be in a perfect circle, or it may have something of a spiral course, and not return exactly to the same spot; for a spiral line is made up of a straight line and a circle. Therefore that these very inequalities have place in the heaven — variety of velocity, and deviation from the point of return, or spirality. For both the fixed stars and the planets are unequal in their velocity; and the planets evidently deviate from tropic to tropic; and the higher the heavenly bodies are, the greater is their velocity, and the more spiral their course. For if phenomena be taken simply and as they are seen, and there be set down one natural and simple daily motion in the heavenly bodies, and the mathematical propriety of reducing motions to perfect circles be rejected, and spiral lines be admitted, and those contrarieties of motions following the order from east to west (which they call the motion of primitive mobility) and again from west to east (which they call the proper motion of the planets) be reduced to one; difference of time in the return being accounted for by differences of

speed, and difference of position with regard to the zodiac by spiral lines, it is plain that what I have said must come to pass — that the moon, for instance, which is the lowest of the planets, must proceed both slowest of all, and in the rarest and most open spirals. Such then appears to be the opinion of this sect respecting the nature of that portion of the heaven which (by reason of its distance from a contrary) is firm and perpetual. But whether Telesius kept to the old limits, and imagined that such was the nature of everything above the moon, together with the moon itself, or whether he held that the hostile force could ascend higher, he does not clearly lay down. But of the earth (which is the stage and seat of the contrary nature) he asserts likewise, that the greatest part is inviolate and undisturbed, and that the heavenly bodies do not penetrate thither. But of what kind it is, he says, need not be inquired. It is enough to consider it endowed with these four natures — coldness, opacity, density, and rest, and those absolute and in no degree impaired. Now the part of the earth towards the surface, being like a crust or rind, he assigns to the generation of things; and supposes all entities any way known to us, even the heaviest, hardest, and those which lie the deepest, as metals, stones, the sea, to consist of earth in some degree changed and wrought by the heat of the heaven, and which has already conceived some heat, radiation, tenuity and mobility, and partakes in short of an intermediate nature between the sun and pure earth. It follows therefore that this pure earth must be depressed below the lowest depths of the sea, the deepest mines, and all generated bodies; and that between this pure earth and the moon, or perhaps

higher, there must be situated a middle nature composed by the temperaments and refractions of heaven and earth. Having thus sufficiently fortified the interior of both kingdoms, he gets up an invasion and war. For he supposes that in the regions lying between the furthest parts of the heaven and the innermost of the earth, there is found all tumult, conflict, and perturbation, as we see in empires whose borders are ravaged by incursions and violence, while the interior provinces enjoy secure peace; that such natures therefore, with their concretions, have the appetite and faculty of constantly generating, multiplying, and spreading themselves in all directions, of occupying the whole mass of matter, of mutually assailing and invading one another, of turning one another out from their proper seats and settling themselves therein; and moreover of perceiving and apprehending the force and actions of another nature as well as their own, and by means of such perception of shifting and adjusting themselves; and that from this contest every variety of entity, action, and virtue is derived. Yet he seems in some places, though hesitatingly and cursorily, to assign to matter some quality of its own; as first, that it is neither increased nor diminished by forms and active entities, but consists of a universal sum; secondly, that to it is referred the motion of gravity or descent; and he also adds something about the blackness of matter. But this is set down plainly, that heat and cold, in the same power and quantity, remit or increase their strength accordingly as the matter in which they exist is opened out or folded up; since they fill the measure of the matter, not their own. But Telesius proceeds to devise and explain the manner in which, by means

of this strife and contest, so fruitful and manifold a generation of beings may be induced and turned out. He begins by securing the earth, as being the inferior principle; and shows the reason why it has not been long ago destroyed and absorbed by the sun, nor ever can be. The first and principal point which he alleges is the immense distance of the earth from the fixed stars, and its very great distance from the sun — a distance tolerably well measured. The second point is the declination of the sun's rays from the perpendicular with respect to the different parts of the earth; that is, that over the greatest part of the earth the sun is never vertical, nor his rays perpendicular; so that he never affects the whole globe of the earth with any remarkable force of heat. The third point is the obliquity of the sun's motion in passing through the zodiac with respect to the same parts of the earth; whence the heat, whatever be its force, is not continually redoubled, but returns after long intervals. The fourth point is the velocity of the sun in its diurnal motion, performing, as it does, so large a circuit in so short a time, whereby the heat stays the less, and is not stationary for an instant. The fifth point is the continuation of bodies between the sun and the earth, whereby the heat of the sun does not come through a vacuum with its force entire, but by passing through so many resisting bodies, with each of which it has to struggle and dispute, is immensely weakened and enfeebled; and so much the more because the further it goes and the weaker it becomes, the more stubborn are the bodies it meets, and most of all when it arrives at the surface of the earth, where there seems not only resistance, but a direct repulsion. But the process of muta-

tion laid down by Telesius is as follows. The war (he holds) is absolutely inexpiable and internecine. These contrary natures do not agree in any one point, nor do they meet in a third, excepting in Hyle. Therefore the one nature desires, strives, and contends absolutely to destroy the other, and to impress matter with itself only and its own image; so that the sun's work (as he says clearly and often) is plainly to turn the earth into sun, and *vice versâ* the earth's work is to turn the sun into earth. This however does not prevent everything being done in certain order, definite times, and just measure; and every action in its due course beginning, working, flourishing, languishing, and ceasing; but this is not caused by any laws of alliance or concord, but entirely by a want of power; for all more and less in virtue and action proceeds not from the regulation of the intensive power (which desires something entire), but from the stroke and curb of the opposite nature. The diversity, multiplicity, and likewise the perplexity of operation must certainly proceed from one of three things; namely, the force of heat, the disposition of matter, or the manner of working; which three are nevertheless united together by a mutual bond, and are causes one of the other. Heat itself differs in power, quantity, continuance, mean, and succession; succession again has its own manifold variations in approaching and withdrawing, or in intension and remission; in sudden or graduated accession; in return or repetition at longer or shorter intervals; and such like alterations. Heats therefore are far the most varied in their force and nature, according as they are made purer or less pure, with reference to the first fountain thereof, namely, the sun. Neither

does all heat cherish heat, but when two heats differ many degrees from one another, either kills and destroys the other no less than cold; each having its proper actions, and thwarting and opposing the actions of the other; so that Telesius makes lesser heats to be as traitors and deserters towards great ones, and as conspiring with cold. Therefore the feeble heat which creeps in water destroys the lively heat which vibrates in fire; and in like manner the preternatural heat of putrid humours in the human body suffocates and extinguishes the natural heat. But that quantity of heat makes a great difference, is too manifest to need explanation. For one or two burning coals are not so hot as a whole heap; but the effect of quantity is most remarkably shown in the multiplication of the sun's heat, by the reflection of the rays; for the number of rays is doubled by simple and multiplied by various reflection. But to quantity of heat there should be added also union; which is likewise best shown in the oblique and perpendicular direction of rays, since the nearer the direct and reflected ray coincide, and the acuter the angle which they make with each other, the stronger is the force of heat thrown out. Moreover the sun himself when he is present among the larger and stronger fires of the fixed stars, Regulus, the Dog Star, and Spica, sends out stronger heats. But continuance of heat is most plainly an operation of the greatest importance; as all natural virtues respect and observe their times, some time being required to put their strength in action, and a good deal to give it full vigour. Therefore continuance of heat converts an equal heat into a progressive and unequal one, because both the preceding and the subsequent heat

are united together; and this is clearly shown in the heats of autumn, inasmuch as they are felt to be more burning than the heats of summer, and in the heats of summer afternoons, inasmuch as they are felt to be more burning than those of noonday. So also the weakness of heat in the colder countries is sometimes compensated by the continuance and length of the days in summer. But the power and efficacy of the medium in conveying heat is wonderful. For hence the temperature of the seasons is exceedingly varied, so that with an unspeakable changeableness it is sometimes found to be chilly in summer and sunny in winter; the sun meanwhile keeping his course and distance constantly and regularly. Crops of corn likewise and grapes ripen sooner with a south wind and a cloudy sky. And every disposition and excretion of the heaven in the various revolutions of years, sometimes pestilent and diseased, sometimes healthy and favourable, derives its cause and origin from this; namely, from the variation of the intermediate air, which gathers a different disposition from the very change and alteration of the seasons, perhaps in a long series. But the succession of heat, and the order in which one follows another, as the reasons of it are manifold, so its virtue is supreme. For the sun could not have generated so numerous and prolific an offspring, did not the configuration of the sun's body as it moves, with respect to the earth and the parts of the earth, partake of very much inequality and variation. For the sun moves both in a circle and rapidly and obliquely, and changes himself, so as to be both absent and present, nearer and further off, more perpendicular and more oblique, returning slowly and quickly, and never for a

single moment is the heat emanating from the sun constant, and nowhere (unless it be in the tropics) does it return at a short interval; so that such variation of the generator excellently agrees with such variety of the thing generated. Whereto may be added the extreme diversity of the nature of the medium or conductor. The other things also, which have been said of the inequality and degrees of a single heat, may be referred to the changes and varieties of succession in different heats. Therefore not without reason did Aristotle attribute the generation and corruption of things to the oblique course of the sun, and set down that as the efficient cause thereof; had he not from his love of laying down the law and of acting as the arbiter of nature, and of distinguishing and arranging things according to his own pleasure, spoiled a sound conception. For he should have assigned generation and corruption (which is never merely privative, but is still pregnant with the generation of something else) to the inequality of the sun's heat as a whole; that is, to his advance and retreat both together; not generation to the advance and corruption to the retreat separately; a thing which he did stupidly and almost according to the vulgar judgment. And if any one is surprised that generation of things is attributed to the sun; seeing the sun is asserted and supposed to be fire, and fire generates nothing; it is a weak objection. For that notion of the heterogeneity of the heats of the sun and of fire is plainly a dream. For there are infinite operations in which the action of the sun and of fire agree; as in the ripening of fruits, the preservation in cold climates of tender plants accustomed to warm skies, the hatching of eggs, the

clarifying of urine (for I put the heat of the sun and of animals together), the reviving of small animals stiffened with cold, the raising of dews and vapours, and the like. Nevertheless our fire is a bad actor, and cannot well imitate or come near to the actions of the sun; for the sun's heat has three properties, which common fire can by scarce any device represent. First by reason of its distance it is less in degree and gentler; this however is a property which may in some measure be matched; for such a measure of heat is rather unknown than unprocurable. Secondly by flowing and shooting through so many and such different mediums, it borrows and obtains a certain dissimilar and generative force. But above all, it is so regular in the inequality with which it increases and diminishes, advances and retreats, never succeeding by starts or precipitately. Which two latter properties are almost inimitable by fire, though the matter may be advanced by a perspicacious and well-considered industry. Such then are the opinions of Telesius respecting the diversity of heats.

But cold, that is, the contrary principle, and the distribution thereof, he scarce mentions; unless he thought that in treating of the disposition of matter (to which I now proceed in the second place) he had sufficiently provided for it. Yet this he should not have done; seeing that he held cold to be by no means the privation of heat, but a decidedly active principle; a rival as it were and competitor with heat. And what he says concerning the disposition of matter goes to show how matter suffers and is worked upon and converted by heat, without any mention or thought about cold. Of cold however (for I wish to deal

quite fairly with every man's opinions, and to give them the benefit of a favourable construction) he might have said something of this kind: — That the immovable and fixed seat of cold answers excellently to the movable and changeable structure of heat; as the anvil to the hammer. For if both principles had been subject to variety and alteration they would doubtless have produced hourly and momentary beings. Likewise that the immense regions of heat (namely, the heavens) are somewhat balanced by the compact nature of the earth and surrounding objects; since it is not space that is regarded, but the quantity of matter in space. But for the nature of cold and its virtues and proportions it is fit they should be passed over in silence, or with few words; seeing no certain and well-approved information can be had concerning it from experience. For we have common fire, as a kind of substitute for the sun, to manifest the nature of heat. But for the cold of the earth there is no substitute which is at man's command and available for experiment. For those chills and rigours of cold which in winter time and in the coldest countries are exhaled into the air from the globe and circumference of the earth are merely tepid airs and baths, compared to the nature of the primal cold shut up in the bowels of the earth; insomuch that that cold whereof men have perception and command is much the same as if they had no other heat than that of the summer sun in hot countries; which as compared with the fire of a burning furnace may be regarded as coolness. However not to dwell longer on supposititious suggestions, let us next see what Telesius says of the disposition of matter on which heat acts; and which has such power

as to promote, impede, and change the very action of heat. It falls under four heads. The first difference is derived from the preexistence or non-preexistence of heat. The second, from the abundance or paucity of matter. The third, from the degree in which it is worked. The fourth, from the closeness or openness of the body worked upon. With regard to the first, Telesius supposes that in all known beings there exists some latent heat, though imperceptible to the touch, which unites itself to the new or supervenient heat; and which is itself moreover excited and inflamed by this same foreign heat to perform its own actions in its proper sphere: of this he says it is a notable argument, that there is no being, — neither metal, nor stone, nor water, nor air, — which does not grow warm at the touch, or even at the approach, of fire or a hot body; which would probably not be so, were there not some preexisting and latent heat to prepare the way for this new and manifest heat. Also that the more or less in this respect, that is the greater or less readiness to catch fire, which is found in beings, corresponds with the measure of preexisting heat. For air warms with a little heat, and such as in the body of water would not be perceptible by the sense. Water likewise warms sooner than stone, or metal, or glass. For though it is true that some of these, as metal or stone, seem to warm sooner than water, that is only on the surface and not in the inner part of the body; for consistent bodies have less free communication in their parts than liquids. Therefore the exterior of metal is warmed sooner than the exterior of water, but the whole body not so soon. The second difference is laid in the collection and bulk of matter. For if this be

close, the strength and heat is more limited, and by union more increased and intensified; on the other hand, if it be loose, the strength is more dispersed, and by dispersion more diminished and weakened. Therefore the heat of ignited metals is stronger than that of boiling water, even than of flame itself, except that flame, by reason of its tenuity, finds easier entrance. For the flame of coals or wood, unless it be excited by blowing, so that the motion may help to drive it in and make it penetrate, is not very furious; nay, some flame (as the flame of spirit of wine, for instance, especially in a small quantity and scattered,) has so gentle a heat that the hand may almost bear it. The third difference, which is taken from the degree in which matter is wrought upon, is manifold; for he mentions some seven degrees of this working: of which the first is pliancy, or that disposition of matter which makes a body yield a little to any great violence, or bear compression, and especially extension; in a word, flexible or ductile. The second is softness, when there is no need of any great violence, but the body yields upon the slightest impulse, and at a touch, without any apparent resistance. The third is viscosity or tenacity, which is a kind of beginning of fluidity. For a viscous body seems at the touch and embrace of another body to begin to flow and continue itself, and not to be terminated in itself; though it does not flow spontaneously and of its own accord; for a fluid follows itself, a viscous body rather something else. The fourth is fluidity itself, where a body partaking of an inner spirit is glad to be in motion, and follows itself, and is not easily defined or fixed. The fifth is vapour, when the body is attenuated into something intangible,

which likewise gives, flows, undulates, and trembles with greater agility and mobility. The sixth is exhalation, which is a kind of vapour more concocted and ripened, and prepared for the reception of a fiery nature. The seventh is air itself; which Telesius contends is actually endowed with a native heat of its own, and that not small or weak; because even in the coldest regions the air is never congealed or frozen. Likewise that we have an evident proof that the air in its own nature is hot, in this: that all air enclosed, separated from the universal body of air, and left to itself, manifestly contracts warmth, as appears in wool and fibrous bodies. Again, in close and confined places the air, when breathed, feels somewhat suffocating; which comes from heat. And that the reason of this is that air, when confined, begins to exercise its nature, whereas the open air out of doors is refrigerated by the cold which the globe of the earth perpetually emits and discharges. Moreover our common air has some slender portion of the qualities of the heavenly bodies; since it contains some light in itself: as is shown by the sight of animals, who can see at night and in dark places. Such then, according to Telesius, is the order of the disposition of matter; in intermediate bodies, that is; for the extremes, namely hard and rigid bodies on the one side, fire itself on the other, as being the limits of those lying between, are not counted. But besides these simple gradations he finds a great diversity in the disposition of matter by reason of similarity and dissimilarity of body; since the various portions of matter, which are compounded and united together in one body, may either be referred equally to some one of the above-mentioned gradations, or unequally to

different ones. For thence arises by far the greatest difference in the operation of heat. Therefore the fourth difference necessarily depends on the nature and also the position of the body on which heat acts, whether it be close or porous and open. For when heat works on an open and exposed nature, it works in succession and part by part, attenuating and at the same time drawing out and separating. But when it works in a confined and compact nature, it operates in the whole and in the mass, without losing any heat, but the old and the new heat plainly uniting and conspiring together; whence it comes that it effects more powerful, more profound, and more exquisite alterations and preparations; of these however I shall presently speak more when I come to the manner of preparation. Meanwhile Telesius labours hard and strangely perplexes himself to explain the manner of the divorce and separation of his primary connatural qualities, heat, light, tenuity, and mobility, and the four opposed to them, according as they take place in bodies; for there are found some bodies hot or excellently prepared for heat, which are also dense, quiet, and dark; others rare, movable, bright or white, yet cold; and in like manner with regard to the rest: there being some one quality existing in things, with which the rest do not agree; and again, others partake of two of these natures, without the other two, with a great variety of permutations and assortments. In which part Telesius does not acquit himself very happily, but behaves like his opponents; who, having formed their opinion before they made the trial, when they come to particulars abuse both their own wit and the facts of nature, and miserably mangle and torture both; and yet they pro-

ceed confidently and (if you believe themselves) victoriously, and by one means or another still find enough to say for themselves. In the end however he gives up in despair, and falls to wishes, intimating that though both the power and quantity of heat and the disposition of matter may be grossly and in sum distinguished and determined, yet their exact and accurate proportions, and their distinct and as it were measured methods, are placed beyond the reach of human inquiry; and yet so that (if of two impossibles one can be said to be easier than another) the diversity of the disposition of matter may be better discerned than the strength and gradations of heat; and nevertheless that in these very things (if the fates allow) is to be found the summit and culmination both of the knowledge and the power of man. But having plainly professed despair, he yet does not cease from vows and prayers. For his words are: "Further, what heat and how much, — that is, what strength and what amount of it, — can turn what earth and what entities into what, — is a question not to be asked; being a thing impossible (as it seems to me) for man to know. For how is it possible to divide, as it were, into degrees either the force of heat or heat itself, or to have a distinct perception of the amount and quantity of matter into which it is infused, and to assign to a certain and determinate force and quantity of heat a certain quantity and disposition and certain actions of matter; or on the other hand, to a certain quantity and certain actions of matter a certain and determinate quantity of heat? Would that they who enjoy leisure and a clearer intellect, and who have the means of searching the nature of things in perfect tranquillity, may find this out; that men

may not only understand all things, but likewise be masters of all!" wherein he shows himself somewhat honester than his adversaries usually are, who set down as absolutely unattainable by art everything which the arts that they themselves have made do not attain; so that no art can be found guilty, being itself both party and judge. There remains the method which was mentioned in the third place, that of working upon; which Telesius disposes of by three dogmas. The first is, what I before remarked by the way, that we know of no concordance (as in the doctrine of the Peripatetics), whereby things are cherished and conspire as by agreement. For all generation, and therefore all effect in the natural body, is accomplished by victory and predominance of one or other, and not league or compact between the two. And this is no new thing, as Aristotle likewise remarked it in the doctrine of Empedocles;[1] namely, that Empedocles, although he had set down strife and friendship as the efficient principles of things, yet in his explanations of causes commonly makes use of hostility, as if forgetful of the other. The second is that heat, by its own action, always turns being into moisture, and that neither dryness has any agreement with heat, nor moisture with cold. For to attenuate is the same as to moisten; and what is rarest is also moistest; by moisture understanding that which yields, divides into parts, and restores itself again most easily, and is defined and fixed with difficulty. All which qualities exist more in flame than in air, which is made by the Peripatetics to be most moist. Therefore heat perpetually attracts, feeds upon, extends, supplies, and generates moisture; and on the

[1] Arist. Meteor. iii. 4.

other hand cold drives all things into dryness, concretion, and hardness: and here he holds Aristotle to be both dull in observation and inconsistent with himself, and imperious and wilful as regards experience, because he unites heat with dryness. For that heat sometimes dries beings, happens by accident; that is to say, in a body dissimilar, and made up of parts some grosser and some finer, heat attracts and (by attenuation) gives an outlet to the finer part, while the grosser part is thereby forced together and more constrained; which grosser part nevertheless, if a stronger heat be applied, itself becomes fluid, as is shown in bricks. For, in the first place, a moderate heat forces the clay to become brick, the finer part having evaporated; but a stronger heat melts this brick substance into glass. Now these two dogmas may be regarded as confutations of errors; the third plainly affirms, and not only that, but also clearly distinguishes the manner of working and preparation. This is twofold, either by rejection or conversion; either of which methods is carried out into acts according to the force of heat and disposition of matter. Yet in this there seem to be, as it were, two rules; one, that when heat and cold meet together in great quantities and in regular armies, there follows an ejection. For the beings are dislodged like armies, and driven from their place. But when a smaller quantity is engaged then there follows conversion; for the beings are destroyed and rather change their nature than their place. Of this there is a remarkable and noble instance in the upper regions of the air, which, though they are situated nearer to the heat of heaven, are yet found to be colder than the confines of the earth. For in those places where a nearer

approach is made to the seat of primitive heat, the heat, collecting itself at once, drives out and thrusts down the entire force of cold that had risen up, and prevents its approach. And it may be, in like manner, that in the depths of the earth the heats are more intense than on the surface; for that as the seat of primitive cold is approached, the cold, exciting itself, drives back and puts to flight the heat with great impetuosity, and converts it into itself. The other rule is, that in an open place there follows ejection; in a confined, conversion. Now this is wonderfully shown in close vessels, where the emission of the rarefied body (which we commonly call spirit) being prevented and driven back, there follow deep and radical alterations and fermentations in bodies. But this in like manner happens when a body, from the compactness of its parts, is itself like a close vessel. Such then are the opinions of Telesius, and perhaps also of Parmenides, concerning the principles of things, except that Telesius has added something of his own respecting Hyle, being led astray by the Peripatetic notions.

Now what Telesius says would have been probable, if man were removed from the world, and with him the mechanical arts which vex matter, and the fabric of the world were regarded simply. For this philosophy of his seems a kind of pastoral philosophy, which contemplates the world placidly and at its ease. Of the system of the world he discourses well enough, but of principles most unskilfully. Moreover in his system itself there is a great mistake; namely, that he frames such a system as may apparently be eternal, without supposing a chaos, or any changes of the great configuration of things. For whatever philosophy it be,

whether the Telesian or the Peripatetic, or any other, that professes a system so furnished, balanced, and guarded, that it may seem not to have come from chaos, it is a philosophy of little value, and conceived in the narrowness of the human breast. For by one who philosophises according to the sense alone, the eternity of matter is asserted, the eternity of the world (such as we now see it) is denied; and this was the conclusion both of the primitive wisdom, and of him who comes nearest to it, Democritus. The same thing is testified by Sacred Writ; the principal difference being, that the latter represents matter also as proceeding from God; the former, as self-existing. For there seem to be three things with regard to this subject which we know by faith. First, that matter was created from nothing. Secondly, that the development of a system was by the word of Omnipotence; and not that matter developed itself out of chaos into the present configuration. Thirdly, that this configuration (before the fall) was the best of which matter (as it had been created) was susceptible. These however were doctrines to which those philosophies could not rise. Creation out of nothing they cannot endure; the existing configuration of the world they suppose to have grown out of many indirect and circuitous processes, and many attempts and efforts of matter: and as for its being the best possible, they do not trouble themselves about that, seeing they maintain it to be perishable and variable. In these points therefore we must rest upon faith and the firmaments of faith. But whether it would have been possible for this created matter, in a long course of ages, by the force which was given to it, to have gathered and shaped itself into that

perfect configuration (as it did at once without any rounding about at the word of command), is a question perhaps not to be asked. For the anticipation of time is as much a miracle, and belongs to the same omnipotence as the formation of being. Now the Divine nature seems to have chosen to manifest itself by both these emanations of omnipotence, by operating omnipotently, first on being and matter in the creation of something out of nothing; secondly on motion and time in anticipating the order of nature and accelerating the process of being. But these things belong to the allegory of Cœlum, where I will discuss more fully what I now briefly glance at. Let us proceed then to the principles of Telesius. And would that this were but agreed on for once by all, that beings are not to be made out of things which have no being; nor principles out of what are not principles; and that a manifest contradiction is not to be admitted. Now an abstract principle is not a being; and again, a mortal being is not a principle; so that a necessity plainly inevitable drives men's thoughts (if they would be consistent) to the atom; which is a true being, having matter, form, dimension, place, resistance, appetite, motion, and emanations; which likewise, amid the destruction of all natural bodies, remains unshaken and eternal. For seeing the corruptions of the greater bodies are so many and various, it must needs be that that which remains as the centre immutable should be either something potential or infinitely small. But it is not potential; for the original potentiality cannot be like other potentialities, which are one thing actually and another potentially. But it must necessarily be something entirely abstract, since it refuses all act and

contains all power. It remains therefore that this immutable thing must be infinitely small; unless indeed it be asserted that there are no principles at all, but that one thing is as a principle to another; that the law and order of change are things constant and eternal, but essence itself inconstant and mutable. And it would be better to affirm directly something of this kind than, from a desire to maintain some eternal principle, to fall into the greater inconvenience of making that principle imaginary. For the former method seems to have some issue; namely, that things change in a circle; whereas this would have none at all, which regards as beings things that are merely notional and instruments of the mind. And yet that this is no way the case, shall be shown hereafter. Telesius however chose *Hyle*, which, though the offspring of a later age, he transferred into the philosophy of Parmenides. But he institutes a strange and altogether unequal contest between his active principles, unequal both in numbers and the method of fighting. For as to numbers, the earth with him is single, while the heaven has a great army; the earth likewise is almost like a point, whereas the space and region of the heaven are immense. Nor can this inconvenience be removed by the assertion that the earth and its connaturals are of a matter most compact, whereas the heavens and the ethereal bodies are of a matter most spread out. For though this certainly makes a considerable difference, yet it by no means equalises the forces, not by a wide interval. But the strength of Telesius's doctrine depends principally upon the possibility of assigning, as it were, an equal portion of Hyle (equal in quantity, not in bulk) to each of the active principles; so that

things may last, and a system be constituted and established. For whoever, agreeing with Telesius in other respects, shall admit the superabundance of Hyle in one principle as compared with the other, especially in so great an excess, will find himself in a difficulty, and will not be able to make it out. Therefore in the dialogue of Plutarch respecting the face in the moon's orb, this consideration is wisely proposed, that it is not probable that in the dispersion of matter nature enclosed every compact body in the globe of the earth alone, when there were so many globes of stars revolving. But Gilbert has indulged this thought to such excess, as to assert that not only the earth and moon, but many other solid and opaque globes are scattered amid the shining globes throughout the expanse of heaven.[1] Nay, the Peripatetics themselves, when they had set down the heavenly bodies as eternal in their own state, and sublunary bodies as eternal by succession and renovation, were not confident of being able to maintain that doctrine without assigning as it were equal portions of matter to the elements. For this is what they are thinking of in that dream of theirs about the tenfold proportion of the ambient to the interior element. Nor do I adduce these things because none of them please me, but to show that it is an inconceivable thing and a thought altogether ill-measured, to set down the earth as the contrary active principle to heaven, which Telesius did. And the supposition becomes much harder, if, besides the difference in quantity between heaven and earth, a man shall consider the difference in virtue and act. For the conditions of battle are entirely destroyed if the weapons on one

[1] Gilbert, Nov. Phys. i. 10.

side take effect, and on the other do not reach their distance, but fall short. Now, it is certain that the sun's force reaches the earth; but who will undertake to say that the earth's force reaches the sun? For of all the virtues which nature produces, that of light and shade is emitted furthest, and spreads round in the widest circle. But the shade of the earth stops on this side of the sun, whereas the light of the sun, if the earth were transparent, would strike quite through the globe of the earth. Heat and cold again (of which we are now speaking) are never found to carry their virtue so far as light and shade. Therefore if the shade of the earth does not reach the sun, much less is it probable that the cold of the earth reaches thither. If it be the case that the sun and heat act on certain intermediate bodies to which the virtue of the contrary principle does not ascend, and where it does not in any way interfere with their action, it must needs be that they (the sun, I say, and heat) first occupy all bodies near them, and then take in those also which are further off, till it would end in the conflagration of Heraclitus, the solar and celestial nature gradually descending, and approaching nearer to the earth and its confines. Nor does it well agree with the supposition, — that this power of imposing and multiplying its nature and converting other things into itself, which Telesius attributes to principles, does not operate on similar things equally or more than on contraries; in which case the heaven should now be of a white heat, and the stars united with one another. But to come closer, it seems there are four demonstrations to be proposed, by any one of which, much more by all together, Telesius's philosophy respecting principles may be pulled to pieces

and destroyed. Of these the first is, that there are found in nature certain actions and effects, even among the most powerful and universal, which can in no way be referred to heat and cold. The second is, that there are found some natures, of which heat and cold are the effects and consequences; and that not by the excitation of preexisting heat, or the application of an adventitious heat, but in which heat and cold, in their original essence, are implanted and generated. Therefore the condition of a principle fails here in both ways; as there is both something that does not proceed from them, and they themselves proceed from something. The third is, that even those things which derive their origin from heat and cold (which certainly are very many) yet proceed from them as from their efficient and instrument, not as from their proper and intimate cause. The last is, that this coordination of four connatural bodies is altogether disordered and confused. I will speak therefore on each of these points separately. And to some it may perhaps seem scarce worth while to take such pains in refuting the philosophy of Telesius, a philosophy not much spoken of or received. But I do not stand upon such points of dignity. For of Telesius himself I have a good opinion, and acknowledge him as a lover of truth, useful to the sciences, the reformer of certain opinions, and the first of the moderns; at the same time it is not as Telesius that I have to do with him, but as the restorer of the philosophy of Parmenides, to whom much respect is due. But my principal reason for being more full in this part is that in dealing with him who comes first, I take occasion to discuss many questions which may be transferred to the refutation of other sects, of which I

shall have to treat hereafter; that I may not be obliged to say the same things many times over. For errors, though different, have their fibres strangely entangled and intertwined; yet so that they may often be mowed down by one refutation as by a sweep of a scythe. But, as I was going to say, we must see what virtues and actions there are in nature, which can by no consent of things or force of wit be attributed to heat and cold. First therefore let us assume what Telesius grants, that the sum of matter is eternal, and without increase or diminution. This property, by which matter preserves and supports itself, he dismisses as passive, and as belonging rather to quantity than to form and action; as if there were no need to ascribe it to heat and cold, which are set down as the sources only of active forms and virtues; for that matter is not destitute simply, but only destitute of all active virtue. Now in these assertions there is a great mental error, — an error truly wonderful, were it not that consent and common and inveterate opinion take away the wonder. For there is scarce any error comparable to that of taking this virtue implanted in matter (by which it saves itself from destruction, insomuch that not the smallest portion of matter can either be overpowered by the whole mass of the world, or destroyed by the force and power of all agents together, or any way so annihilated and reduced to order, but that it both occupies some space, and maintains a resistance with impenetrable dimensions, and itself attempts something in its turn, and never deserts itself) not to be an active virtue; whereas, on the contrary, it is of all virtues far the most powerful, and plainly insuperable, and as it were mere fate and necessity. And yet Telesius does

not even attempt to refer this virtue to heat and cold. And rightly so; for it is a thing which neither conflagration, nor torpor and congelation, can add anything to or detract anything from or have any power over, while itself meantime is active both in the sun and at the centre of the earth, and everywhere else. But his mistake appears to have lain here — that while he acknowledges a certain and definite mass of matter, he is blind to the virtue by which that matter keeps itself undiminished in quantity, and (buried in the deepest darkness of the Peripatetics) ranks this as an accessory; whereas it is the very principal, — vibrating one body, removing another, solid and adamantine in itself, and the fountain whence emanate the decrees of possible and impossible with inviolable authority. The common school philosophy likewise childishly attempts to grasp it in a set of words; thinking it enough to set it down as a rule that there cannot be two bodies in the same place; but the virtue and the process thereof it never contemplates with its eyes open, nor dissects to the quick; little knowing how much depends on it, and what a light may thence rise to the sciences. But (to return to the present business) this virtue, however great it be, falls beyond the principles of Telesius. I must now pass on to that virtue which is as the converse of the former, namely, that which maintains the connexion of matter. For as matter refuses to be overpowered by matter, so does matter refuse to be separated from matter. Notwithstanding there is great doubt whether this law of nature be as peremptory as the other. For Telesius maintained, and so did Democritus, the existence of a collective vacuum without any limit, in order that individual beings may lay aside

and sometimes even forsake the one contiguous to them, with difficulty (as they say) and against their will, — that is, when subdued and forced by some greater violence; and this he tries to prove by certain experiments, especially adducing those which are everywhere cited for the contradiction and refutation of a vacuum, and as it were making extracts from them, and amplifying them so as to allow beings to be under some slight necessity of holding to that which is contiguous, but so that if they be more strongly pressed, they will admit a vacuum; as we see in water-clocks, in which if the hole through which the water runs is too small, they will want an air-hole to enable the water to descend; but if the hole be larger, even though there be no air-hole, the water, pressing with a heavier weight on the hole, flows downwards, not caring for the vacuum above. In like manner, in bellows, if you shut them and then stop the mouth so that there is no passage for the air to enter, and then raise and expand them, — if the leather be thin and weak it bursts; if it be thick and not liable to burst it holds; and so in other things. But these experiments are neither exactly proved nor do they altogether satisfy the inquiry or settle the question; and though by them Telesius thinks that he is applying himself to things and inventions, and endeavours to distinguish more accurately what has been observed confusedly by others, yet he is no way equal to the work, nor does he unravel the matter to the end, but falls off in the middle, — a habit common both to him and the Peripatetics; who are very owls in looking at experiments; and that not so much from weakness of vision, as because it is clouded by opinions, as by cataracts, and

from impatience of full and fixed consideration. But this question (one of the most difficult) as to how far a vacuum is allowed, and at what distances seeds may attract or repel each other, and what there is in this matter peremptory and invariable, I refer to the place where I shall treat of a vacuum. For it is not of much importance to the present question whether Nature utterly abhors a vacuum, or whether beings (as Telesius thinks it more correct to say) delight in mutual contact. For I make it plain, that this, whether it be abhorrence of vacuum or desire of contact, no way depends on heat and cold; nor is it ascribed thereto by Telesius himself, nor can it be ascribed to them upon any evidence in the nature of things; seeing matter when moved from its place cannot but draw other matter to it, whether it be hot or cold, wet or dry, hard or soft, friendly or unfriendly; insomuch that a hot body will sooner attract the coldest body to its side, than suffer itself to be deserted and separated from all. For the bond of matter is stronger than the enmity of heat and cold; nor does the sequacity of matter care for the diversity of special forms. Therefore this virtue of connexion does not at all depend upon those principles of heat and cold. Next come two virtues opposed to each other, by which this kingdom of principles has been transferred (as may be thought) to heat and cold, but on a claim of right not well made out; I mean those virtues by which beings open and rarefy, dilate and expand themselves, so as to occupy a greater space and spread themselves over a larger sphere; or contrariwise close and condense, confine and contract themselves, so as to cover less space and shrink into a smaller sphere. We

must show therefore how far this virtue has its origin from heat and cold, and how far it keeps separate and unmixed with them. Now it is most true, as Telesius affirms, that density and rarity are as it were the proper work of heat and cold; for they have far the most to do in making bodies occupy a larger or less space; but yet these things are understood confusedly. For bodies seem sometimes to migrate and transfer themselves from one natural dimension to another, and that freely and as it were willingly, and with a change of form; sometimes they seem only to be forced away from their natural dimension, and their old form still remaining, to return to their usual dimension again. Now that virtue of progression into a new space is almost governed by heat and cold. But it is not so with that other virtue of restitution; since water expands itself into vapour and air, oil likewise and fat things into exhalation of flame, by the power of heat; nor (if the transmigration be perfect) do they care to return; nay the air itself also swells and is extended by heat. Whereas if the migration be only half effected, then after the heat is withdrawn it easily returns to itself; so that even in the virtue of restitution heat and cold have something to do. But things which are extended and drawn asunder not by means of heat, but by some violence, as soon as the violence ceases return most eagerly (even without any accession of cold or diminution of heat) to their former dimensions; as we see in the sucking of the glass egg, and the raising of the bellows. But this is still more evident in solid and gross bodies. For if a piece of cloth or a harp-string be stretched, on the removal of the force they rebound with great velocity; and it is the same with compres-

sion. For air compressed and imprisoned by any violence bursts out with a great force; and indeed all that mechanical motion caused by the striking of one hard body by another, commonly termed violent motion, by which solid bodies are sent flying through the air and water, is nothing but an endeavour of the parts of the discharged body to free themselves from compression; and yet here there are no apparent traces of heat and cold. Nor can any such fine argument be made upon this doctrine of Telesius, as to say, that to every natural dimension there is assigned a quantity of heat and cold, in a certain proportion; therefore it may be that although no heat and cold are added, yet if the dimensions of the material body be extended or contracted it will come to the same thing; because more or less of matter is put in the space than is proportionate to the heat and cold. Such things, though not absurd in words, are yet the suggestions of men who are always seeking some device by which they may maintain their first thought, and do not follow out the inquiry in nature and fact. For if heat and cold be added to such extended or compressed bodies, and that in a greater measure than is proportionate to the nature of the body itself (let the stretched cloth for instance be warmed by the fire), yet it will by no means restore the balance, nor extinguish the force of restitution. I have therefore now made it plain that this virtue of dimension does not depend in any notable proportion on heat or cold; although it is this very virtue which has given most authority to these principles. Next come two virtues, which are in everybody's mouth, and are spread far and wide, namely those by which bodies are carried

towards the greater masses and collections of their connaturals; in the observation whereof, as in the rest, men either trifle or go quite wrong. For the common philosophy of the school holds it enough to distinguish natural from violent motion; and to assert that heavy bodies by a natural motion are borne downwards and light bodies upwards. But such speculations are of little help to philosophy. For these words, *nature*, *art*, and *violence*, are but compendious phrases and trifles. They ought not only to refer this motion to nature, but likewise to seek in this very motion for the particular and proper affection and appetite of the natural body. For there are a great many other natural motions arising from very different passions of things. Therefore the thing is to be propounded according to its differences. Nay, those very motions which they call violent may be said to be more according to nature than that which they call natural; if that be more according to nature which is stronger, or even which is more according to the system of the universe. For this motion of ascent and descent is not very imperious, nor even universal; but provincial as it were, and confined to certain regions; and it is moreover obedient and subject to other motions. And as for saying that heavy things move downwards and light upwards, it is the same as saying that heavy things are heavy and light light. For that which is predicated is assumed in the subject by the very force of the term. But if by heavy they mean dense and by light rare, they do advance somewhat; yet so as to arrive at an adjunct and concomitant rather than a cause. Those on the other hand who explain the appetites of heavy and light things by contending that the one

are borne to the centre of the earth, and the other to the circumference and compass of the heaven, as to their proper places, certainly assert something, and likewise point towards a cause; but altogether wrongly. For place has no forces, nor is body acted on except by body; and all swift motion of a body, which seems as if it were seeking a place for itself, is really in pursuit not of location or position simply, but with reference to some other body.

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DESCRIPTION

OF THE

INTELLECTUAL GLOBE.

A DESCRIPTION

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CHAPTER I.

Division of all Human Learning into History, Poesy, and Philosophy, *according to the three faculties of the mind*, Memory, Imagination, and Reason: *and that the same division holds good likewise in Theology; the vessel (that is, the human understanding) being the same, though the matter and the manner of conveyance be different.*

I ADOPT that division of human learning which corresponds to the three faculties of the understanding. Its parts therefore are three; History, Poesy, and Philosophy. History is referred to the Memory; poesy to the Imagination; philosophy to the Reason. And by poesy here I mean nothing else than feigned history. History is properly concerned with individuals; the impressions whereof are the first and most ancient guests of the human mind, and are as the primary material of knowledge. With these individuals and this material the human mind perpetually exercises itself, and sometimes sports. For as all knowledge is

the exercise and work of the mind, so poesy may be regarded as its sport. In philosophy the mind is bound to things; in poesy it is released from that bond, and wanders forth, and feigns what it pleases. That this is so any one may see, who seeks ever so simply and without subtlety into the origins of intellectual impressions. For the images of individuals are received by the sense and fixed in the memory. They pass into the memory whole, just as they present themselves. Then the mind recalls and reviews them, and (which is its proper office) compounds and divides the parts of which they consist. For the several individuals have something in common one with another, and again something different and manifold. Now this composition and division is either according to the pleasure of the mind, or according to the nature of things as it exists in fact. If it be according to the pleasure of the mind, and these parts are arbitrarily transposed into the likeness of some individual, it is the work of imagination; which, not being bound by any law and necessity of nature or matter, may join things which are never found together in nature and separate things which in nature are never found apart; being nevertheless confined therein to these primary parts of individuals. For of things that have been in no part objects of the sense, there can be no imagination, not even a dream. If on the other hand these same parts of individuals are compounded and divided according to the evidence of things, and as they really show themselves in nature, or at least appear to each man's comprehension to show themselves, this is the office of reason; and all business of this kind is assigned to reason. And hence it is evident that from these three fountains flow these three emanations, His-

tory, Poesy, and Philosophy; and that there cannot be other or more than these. For under philosophy I include all arts and sciences, and in a word whatever has been from the occurrence of individual objects collected and digested by the mind into general notions. Nor do I think that there is need of any other division than this for Theology. For the informations of revelation and of sense differ no doubt both in matter and in the manner of entrance and conveyance; but yet the human spirit is one and the same; and it is but as if different liquors were poured through different funnels into one and the same vessel. Therefore I say that Theology itself likewise consists either of sacred history, or of divine precepts and doctrines, as a kind of perennial philosophy. And that part which seems to fall outside this division (that is, prophecy) is itself a species of history, with the prerogative of divinity wherein times are joined together, that the narrative may precede the fact; and the manner of delivery, both of prophecies by means of visions and of divine doctrine by parables, partakes of poesy.

CHAP. II.

Division of History into Natural and Civil; Ecclesiastical and Literary History being included under Civil. Division of Natural History into History of Generations, Preter-generations, and Arts, according to the three states of Nature, namely, Nature Free, *Nature* Erring, *and Nature* Constrained.

History is either Natural or Civil. Natural history relates the deeds and actions of nature; civil history

those of men. Matter of Divinity shows itself no doubt in both, but more in civil; so much so indeed as to constitute a distinct species in history, which we call Sacred or Ecclesiastical. This therefore I attribute to Civil; but first I will speak of Natural. Natural history does not treat of particular objects separately. Not that I was wrong in saying that history deals with individuals, circumscribed by place and time. For properly it is so. But since there is in natural objects a promiscuous resemblance one to another, insomuch that if you know one you know all, it would be a superfluous and endless labour to speak of them severally. And therefore we see that where there is no such promiscuous resemblance, natural history does take in individuals; such I mean of which there is not a body, or nation as it may be called. For of the sun, moon, earth, and the like, which are unique in their species, it is very right that separate histories should be written; nor less of such things as notably deviate from their species, and are prodigies; since in their case a description and knowledge of the species itself is neither sufficient nor competent. These two kinds of individuals therefore natural history does not reject; but for the most part (as has been said) it is concerned with species. But I will make the division of natural history according to the force and condition of nature itself; which is found in three states, and subject as it were to three kinds of regimen. For nature is either free, and allowed to go her own way and develop herself in her ordinary course; that is when she works by herself, without being any way obstructed or wrought upon; as in the heavens, in animals, in plants, and in the whole array of nature;—or again she is forced and driven quite out of her course

by the perversities and insubordination of wayward and rebellious matter, and by the violence of impediments; as in monsters and heteroclites of nature; — or lastly, she is constrained, moulded, translated, and made as it were new by art and the hand of man; as in things artificial. For in things artificial nature seems as it were made, whereby a new array of bodies presents itself, and a kind of second world. Natural history therefore treats either of the *liberty* of nature or her *errors* or her *bonds*. And if any one dislike that arts should be called the bonds of nature, thinking they should rather be counted as her deliverers and champions, because in some cases they enable her to fulfil her own intention by reducing obstacles to order; for my part I do not care about these refinements and elegancies of speech; all I mean is, that nature, like Proteus, is forced by art to do that which without art would not be done; call it which you will, — force and bonds, or help and perfection. I will therefore divide natural history into history of generations, history of pretergenerations, and history of arts; which I also call mechanical and experimental history. And I am the rather induced to set down the history of arts as a species of natural history, because it is the fashion to talk as if art were something different from nature, so that things artificial should be separated from things natural, as differing totally in kind; whence it comes that most writers of natural history think it enough to make a history of animals or plants or minerals, without mentioning the experiments of mechanical arts (which are far the most important for philosophy); and not only that, but another and more subtle error finds its way into men's minds; that of looking upon art merely as

a kind of supplement to nature; which has power enough to finish what nature has begun or correct her when going aside, but no power to make radical changes, and shake her in the foundations; an opinion which has brought a great deal of despair into human concerns. Whereas men ought on the contrary to have a settled conviction, that things artificial differ from things natural, not in form or essence, but only in the efficient; that man has in truth no power over nature, except that of motion — the power, I say of putting natural bodies together or separating them — and that the rest is done by nature working within. Whenever therefore there is a possibility of moving natural bodies towards one another or away from one another, man and art can do everything; when there is no such possibility, they can do nothing. On the other hand, provided this motion to or from, which is required to produce any effect, be duly given, it matters not whether it be done by art and human means, or by nature unaided by man; nor is the one more powerful than the other. As for instance when a man makes the appearance of a rainbow on a wall by the sprinkling of water, nature does the work for him, just as much as when the same effect is produced in the air by a dripping cloud; and on the other hand when gold is found pure in sands, nature does the work for herself just as much as if it were refined by the furnace and human appliance. Sometimes again the ministering office is by the law of the universe deputed to other animals; for honey, which is made by the industry of the bee, is no less artificial than sugar, which is made by man; and in manna (which is a thing of like kind) nature asks no help, but does all herself. Therefore as nature is

one and the same, and her power extends through all things, nor does she ever forsake herself, these three things should by all means be set down as alike subordinate only to nature; namely, the course of nature; the wandering of nature; and art, or nature with man to help. And therefore in natural history all these things should be included in one continuous series of narratives; as indeed Pliny has in great part done; who conceived an idea of natural history suitable to its dignity, but handled it in a manner most unworthy of the conception. Let this then be the first division of natural history.

CHAP. III.

Division of Natural History according to its use and end; and that by far the noblest end of Natural History is to lay a foundation for Philosophy; and that such a history (a history framed with a view to that end) is wanting.

NATURAL history, which in subject (as I said) is threefold, is in use twofold. For it is used either for the sake of the knowledge of the things themselves which are committed to it, or as the primary material of philosophy. Now the noblest end of natural history is this; to be the stuff and matter of true and lawful induction; and to draw from the sense enough to inform the intellect. For that other kind which aims either to please by the agreeableness of the narrative, or to help by the use of experiments, and is pursued for the sake of such pleasure or such profit, is an inferior thing, and in its very kind of less value, than that

which is qualified to be a proper preparative for the building up of philosophy. For this is that natural history which constitutes a solid and eternal basis of true and active philosophy; this it is which gives the first spark to the pure and real light of nature; and whose genius being neglected and not propitiated, has caused us to be visited most unhappily by that host of spectres and kingdom of shadows which we see flitting about among the philosophies, afflicting them with utter barrenness in respect of works. Now I affirm and bear witness that a natural history properly adapted to this end is not extant, but is wanting, and should be set down among the deficients. And let no man be so dazzled either by the great names of ancient writers or the great volumes of modern, as to think this complaint of mine unjust. I know well that a natural history is extant, large in bulk, pleasing in variety, curious often in diligence; and yet strip it of fables, antiquities, quotations and opinions of authors, empty disputes and controversies, philology and ornaments (which are more fitted for table-talk and the *noctes* of learned men than for the institution of philosophy), and it will shrink into small compass; so that it would seem as if people were engaged in getting up a treasure-house of eloquence, rather than a sound and faithful narrative of facts. Besides, it is not of much use to recount or to know the exact varieties of flowers, as of the iris or tulip, no, nor of shells or dogs or hawks. For these and the like are but sports and wanton freaks of nature, and almost approach to the nature of individuals. And though they involve an exquisite knowledge of the particular objects, the information which they afford to the sciences is slight and almost useless. And yet

these are the things which our ordinary natural history takes pride in. And while it descends to matters which do not belong to it, and indulges to excess in matters superfluous, on the other hand its great and solid parts are either entirely omitted or carelessly and lightly treated. And indeed in the whole course of inquiry pursued and the whole mass of matter gathered, it appears to be in no way adapted or qualified for the end which I have mentioned, namely the building up of philosophy. This will be best shown in the particular branches of it, and by comparing the history of which I am now going to set forth a description, with that which we have.

CHAP. IV.

Beginning of a treatise showing of what nature the required history should be; namely the Natural History which is to serve as a foundation of Philosophy. *For the clearer explanation of this, a division of the* History of Generations *is first subjoined. This is digested into five parts. The first the* History of the Heavens; *the second, the* History of Meteors; *the third, the* History of Earth *and* Sea; *the fourth, the* History of Collegia Majora, *or* Elements *or* Masses; *the fifth, the* History of Collegia Minora, *or* Species. *The history of* Primary Virtues *is postponed, till the explanation of this first division, of* Generations, Preter-generations, *and* Arts, *is concluded.*

ALTHOUGH I consider myself bound not to leave the completion of this history which I pronounce deficient

to others, but to take it upon myself; because the more it may seem a thing open to every man's industry, the greater fear there is that they will go astray from my design; and I have therefore marked it out as the third part of my instauration; yet that I may still keep true to my plan of giving either explanations or specimens of those things which are wanting, and likewise that in case of my death there may be something saved, I think fit now in this place to set down my opinion and advice in this matter. Of the History of Generations or Nature at large I set down five parts. These are the History of Ether. The History of Meteors and of the Regions of the Air, as they are called; for the sublunar region down to the surface of the earth, and the bodies situated upon it, I assign to the history of meteors; Comets likewise of all kinds (however the truth may be) yet for the sake of order I include among meteors. Third comes the History of the Earth and Sea, which together make up one globe. And so far the nature of things is distributed according to places and positions. The two remaining parts distinguish the substances of things or rather masses. For connatural bodies are congregated into greater and lesser masses; which I commonly term greater and lesser Colleges, and which are related to one another in the polity of the world as tribes or families. Therefore fourth in order is placed the History of Elements or the Greater Colleges; fifth and last, the History of Species or the Lesser Colleges. For I mean by Elements not the commencements of things, but only the greater masses of connatural bodies. Now this greatness of mass is owing to the texture of the matter of which they are composed being easy, simple, obvious,

and prepared; whereas species are sparingly supplied by nature, because the texture of matter is complex, and in most cases organic. As for those virtues which may be regarded as cardinal and universal in nature, as Dense, Rare, Light, Heavy, Hot, Cold, Consistent, Fluid, Similar, Dissimilar, Specific, Organic, and the like, together with the motions contributing to them, as Resistance, Connexion, Contraction, Expansion, and the rest (the history of which I would by all means have collected and constructed, even before we come to the work of the intellect), I will treat of the history of these and of the manner of constructing it, when I have completed the explanation of this triple division, of Generations, Preter-generations, and Arts. For I have not included it in that threefold division, because it is not properly a history, but as it were a middle term between history and philosophy. But now I will speak of the History of the Celestial Bodies, and give precepts concerning them, and then of the rest.

CHAP. V.

The history of Celestial Bodies *is resumed; showing both what it should be in kind; and that the legitimate ordering of such a history turns on three kinds of precepts; namely, the End, the Matter, and the Manner of Construction.*

I WOULD have the History of Celestial Bodies simple, and without any infusion of dogmas; all theoretical doctrine being as it were suspended: a history embracing only the phenomena themselves (now almost

incorporated with the dogmas) pure and separate; a history in short, setting forth a simple narrative of the facts, just as if nothing had been settled by the arts of astronomy and astrology, and only experiments and observations had been accurately collected and described with perspicuity. In which kind of history there is nothing extant which satisfies me. Something of the kind indeed Pliny has touched on cursorily and loosely; but that would be the best history of the celestial bodies which might be extracted and worked out from Ptolemæus and Copernicus and the more learned writers on astronomy, taking the experiments detached from the art, and adding the observations of more modern writers. It may seem strange that I should wish to recall to their primitive rudeness and the simplicity of naked observations things so laboriously produced, advanced, and amended. But the truth is that, without meaning to throw away the benefit of former inventions, I am attempting a far greater work: for it is not merely calculations or predictions that I aim at, but philosophy: such a philosophy I mean as may inform the human understanding, not only of the motion of the heavenly bodies and the period of that motion, but likewise of their substance, various qualities, powers, and influences, according to natural and certain reasons, free from the superstition and frivolity of traditions; and again such as may discover and explain in the motion itself, not what is accordant with the phenomena, but what is found in nature herself, and is actually and really true. Now it is easy to see, that both they who think the earth revolves, and they who hold the *primum mobile* and the old construction, are about equally and indifferently

supported by the phenomena. Nay, and the author of the new construction in our own day, who made the sun the centre of the *secundum mobile*, as the earth of the *primum mobile*, whereby the planets in their proper revolutions would seem to wheel in dance round the sun (as some of the ancients suspected to be the case with Venus and Mercury), if he had thought the matter fairly out, might probably have brought it to a very good conclusion. Nor have I any doubt but that other similar constructions might by wit and severe thought be invented. Neither indeed do they who propose these theories mean to say that the things they allege are actually true, but only that they are convenient hypotheses for calculations and the construction of tables. But my plan has a different aim; for I seek not for ingenious adjustments, which may be many, but for the truth of the thing, which is simple. And to this a history of phenomena kept pure and simple will open the way, while one tinctured with dogma will obstruct it. I may say also, that as I hope for the discovery of the truth regarding the heavenly bodies from a history made and compiled according to my principle, by itself alone; so I rest that hope much more upon observation of the common passions and desires of matter in both globes. For those supposed divorces between ethereal and sublunary things seem to me but figments, superstitions mixed with rashness; seeing it is most certain that very many effects, as of expansion, contraction, impression, cession, collection into masses, attraction, repulsion, assimilation, union, and the like, have place not only here with us, but also in the heights of the heaven and the depths of the earth. Nor have we any more faithful interpreters to

consult, in order that the human understanding may penetrate the depths of the earth, which are never seen at all, and the heights of heaven which are for the most part seen untruly. Most excellently therefore did the ancients represent Proteus, him of the many shapes, to be likewise a prophet triply great; as knowing the future, the past, and the secrets of the present. For he who knows the universal passions of matter and thereby knows what is possible to be, cannot help knowing likewise what has been, what is, and what will be, according to the sums of things. Therefore the best hope and security for the study of celestial bodies I place in physical reasons; meaning by physical reasons not such as are commonly supposed, but only the doctrine concerning those appetites of matter which no diversity of regions or places can distract or dissever. Not that on this account (to return to my design) I would have any diligence spared in descriptions and observations of the celestial phenomena themselves. For the fuller our supply of such appearances, the readier and surer will everything be. But before I speak more of this, I have to congratulate both the industry of mechanics, and the zeal and energy of certain learned men, that now of late by the help of optical instruments, as by skiffs and barks, they have opened a new commerce with the phenomena of the heavens; an undertaking which I regard as being both in the end and in the endeavour a thing noble and worthy of the human race; the rather because these men are as much to be praised for their honesty as for their boldness; seeing that they have ingenuously and perspicuously explained the manner in which each point of their proceeding in each case has been

made out. All that is wanted further is constancy and great severity of judgment, to change the instruments, to increase the number of witnesses, to try each particular experiment many times and many ways; lastly, to suggest to themselves and open to others every objection that can be made, not despising even the minutest scruple; lest it fare with them as with Democritus in the matter of the sweet figs, when it turned out that the old woman was wiser than the philosopher, and that a vast and wonderful speculation was built upon a trifling and ridiculous mistake. But now having made these general remarks by way of preface, let us go on to a description of the history of celestial bodies more at large, to show what and what kind of things are to be sought concerning them. First, therefore, I will set down the questions in nature, at least some of them, and those the chief; to these I will add the uses which may probably be derived to man from the study of celestial bodies; both of these as being the mark at which the history aims; that they who undertake to compose a history of the heavens may know what we are about, and may keep these questions, together with these operations and effects, in mind and view; and so proceed to form such a history as shall be adapted to the solution of the said questions, and the procuring of such fruits and benefits to the human race. Now the questions I mean are of that kind which inquire of the fact in nature, not of causes. For this is the proper business of history. Next, I will show distinctly in what the history of celestial bodies consists, and what are its parts; what things are to be understood or inquired, what experiments to be collected and procured, what

observations to be employed and sifted; propounding as it were certain Inductive Topics, or Articles of Interrogation concerning the heavens. Lastly, I will give some precepts, not only concerning that which should be sought, but also how the matters under inquiry are to be examined and how presented and put in writing; that the diligence of the first inquiry may not be lost in passing it on, nor (what is worse) the beginning of the work, on which the subsequent progress depends, prove weak and fallacious. In short I will explain both what should be inquired with regard to the heavenly bodies, and with what view, and in what manner.

CHAP. VI.

That philosophical questions concerning the Celestial Bodies, *even such as are contrary to opinion, and somewhat harsh, should be received. Five questions are propounded concerning the system itself; namely,* is there a system? *if there be,* what is the centre of it, what the depth, what the connexion, and what the position of the parts?

Most men no doubt will think that I am digging up the remains of old questions long since laid up and buried, and in a manner raising their ghosts, and mixing fresh questions with them. But since the philosophy of which we are hitherto in possession concerning the heavens has no soundness; and since it is my constant determination to refer everything to a new trial by legitimate induction; and since if any questions are

passed over, there will be so much less pains and diligence bestowed on the history, because it will perhaps seem superfluous to inquire of things concerning which no question has been raised; I hold it necessary to take in hand all questions which the nature of things anywhere presents. Nay, the less certain I am concerning the questions which are to be determined by my method, the less difficulty do I make in entertaining them. For I see an end of the matter. The first question therefore is, *whether there be a system?* that is, whether the world or universe compose altogether one globe, with a centre; or whether the particular globes of earth and stars be scattered dispersedly, each on its own roots, without any system or common centre? Certainly the school of Democritus and Epicurus boasted that their founders had overthrown the walls of the world; yet this did not absolutely follow from their words. For when Democritus had set down matter or seeds as infinite in quantity and finite in attributes and power, as moving about, and never located in any position from all eternity, he was driven by the very force of this opinion to constitute multiform worlds, subject to birth and death, some well ordered, others badly put together, even essays of worlds and vacant spaces between. But yet though this were admitted, there was no reason why that part of matter which is assigned to this particular world which is visible to us, should not have the shape of a globe. For each one of those worlds must have received some shape; and although there can be no middle point in infinity, yet in the parts of infinity a round figure may exist, no less in a world than in a ball. Now Democritus was a good dissector of the world, but in the

integral parts of the world inferior even to the ordinary philosophers. But the opinion of which I am now speaking, which destroyed and confounded system, was that of Heraclides Ponticus, Ecphantus, and Nicetas of Syracuse, and most of all Philolaus, and likewise, in our own day, of Gilbert, and all those (except Copernicus) who believed that the earth was a planet and movable, and as it were one of the stars. And the effect of this opinion is that the several planets and stars, together with innumerable other stars which elude our sight by reason of their distance, and others again which are invisible to us from their nature being not lucent but opaque, having each of them obtained their own globes and primary forms, are scattered and suspended through that immense expanse which we behold above us, whether it be of vacuum or some thin and almost indifferent body, like so many islands in an immense sea, and revolve not round any common centre, but each separately round its own; some simply, others with some progressive motion of the centre. Now the harshest thing in this opinion is, that they take away quiet or immobility from nature. But it seems that as there are bodies in the universe which revolve, that is, which move with an infinite and perpetual motion, so on the other hand there should be some body which is at rest; between which comes a middle nature, of such as move in a straight line; seeing that motion in a straight line suits the parts of globes, and things banished from their native countries, which move towards the globes of their connaturals, that being united with them they may themselves also either revolve or rest. But this question (namely, *whether there be a system*) will be answered by that

which shall be determined concerning the motion of the earth, that is, *whether the earth stands still or revolves*, and the substance of the stars, *whether they are solid or flamy*, and the ether or interstellar spaces in the heaven, *whether they consist of body or vacuum*. For if the earth be stationary and the heavens revolve in a diurnal motion, there is doubtless a system; but if the earth revolve, it does not necessarily follow that there is no system; because there may be some other centre of the system; the sun, for instance, or something else. Again, if the globe of the earth be the only one dense and solid, it would seem that the matter of the universe is collected and condensed to that centre; but if it be found that the moon or some of the planets consist likewise of dense and solid matter, it would seem that dense bodies collect not to any one centre, but dispersedly, and as it were fortuitously. Lastly, if it be asserted that there is a collective vacuum in the interstellar spaces, it would seem that each globe has round it an emanation of rarer substance, and beyond that a vacuum. But if these spaces be filled with body, it would seem that there is a union of dense things in the middle, and a repulsion of rarer things to the circumference. Now it is of great importance to science to know the conjugations of questions; because in some cases there is history or inductive matter by which they may be settled, in others not so. But granting that there is a system, we come next to the second question, *what is the centre of that system?* For if any one of the globes is to occupy the position of centre, there are two especially, which offer themselves as having the nature of a middle or centre; namely, the earth and the sun. In

favour of the earth, we have the evidence of our sight, and an inveterate opinion; and most of all this, that as dense bodies are contracted into a narrow compass, and rare bodies are widely diffused (and the area of every circle is contracted to the centre), it seems to follow almost of necessity that the narrow space about the middle of the world be set down as the proper and peculiar place for dense bodies. In favour of the sun, on the other hand, we have this consideration, that that body which has the chief office in the system should occupy that place from which it may best act on the whole system and communicate its influence. And since the sun is that which seems most to vivify the world by imparting heat and light, it appears to be altogether right and in order that it should be placed in the middle of the world. Besides, the sun manifestly has Venus and Mercury as his satellites, and in the opinion of Tycho the other planets also; whence it is plain that the sun can sustain the nature of a centre, and perform its office in some things, and so has the better title to be constituted the centre of the universe; as was asserted by Copernicus. Nevertheless, in the system of Copernicus there are found many and great inconveniences; for both the loading of the earth with a triple motion is very incommodious, and the separation of the sun from the company of the planets, with which it has so many passions in common, is likewise a difficulty, and the introduction of so much immobility into nature, by representing the sun and stars as immovable, especially being of all bodies the highest and most radiant, and making the moon revolve about the earth in an epicycle, and some other assumptions of his, are the speculations of one who

cares not what fictions he introduces into nature, provided his calculations answer. But if it be granted that the earth moves, it would seem more natural to suppose that there is no system at all, but scattered globes, according to the opinion of those I have already mentioned, than to constitute a system in which the sun is the centre. And this the consent of ages and of antiquity has rather embraced and approved. For the opinion concerning the motion of the earth is not new, but revived from the ancients, as I said; whereas the opinion that the sun is the centre of the world and immovable is altogether new (except one verse, wrongly translated), and was first introduced by Copernicus.[1] Then comes the third question, concerning the depth of the system; not with a view to find its exact measure, but to ascertain *whether the starry heaven be like one region, or orb, as it is commonly called;* or *whether of the fixed stars, as they call them, some are higher than others, with an immeasurable depth between?* For it cannot be that they are of equal height, if the words be taken exactly; since the stars are certainly not situated as in a plain, so as to have a superficial dimension only, like spots or bubbles, but they are entire globes, great and deep; and being of such different magnitudes, it must needs be that some protrude more than others either upwards or downwards, nor is it possible for them to be united in one surface, either above or below. And if this be the case in the parts of stars, it would plainly be rash to assert that there are not some stars higher than others in their whole body. But though this be true, it may nevertheless be maintained that the width of that region which they

[1] The allusion is to Job ix. 6.

call the sphere or starry heaven, though great, is definite; and that within this those prominences and degrees of altitude are in a manner limited; for we see from the apogees and perigees of the planets that every one of their heavens through which they ascend and descend has an observable width. But the question proposed relates only to this, — whether some stars are above others, like planet above planet, and as it were in different orbs. And this question is in like manner related to that other concerning the motion or fixedness of the earth. For if the stars move in a diurnal motion round the earth, since they all move with the same velocity, and as it were with one spirit (and since it is very evident in planets that as they vary in height and lowness of position, so they vary in quickness and slowness of motion), it is probable that the stars, being equal in velocity, are situated likewise in one region of the ether, the width or profundity of which, although it be great, yet is not so great as to make a difference in the velocity or quickness of motion; but so that throughout the whole of that region everything being united together by a kind of bond of connaturality revolves equally, or at least with so little difference that at this distance it is not visible to the sight. But if the earth moves, the stars may either be stationary, as Copernicus thought, or, as is far more probable, and has been suggested by Gilbert, they may revolve each round its own centre in its own place, without any motion of its centre, as the earth itself does; if only you separate that diurnal motion of the earth from those two supposititious motions which Copernicus superadded. But either way, there is no reason why there should not be stars above stars till they go be-

yond our sight. The fourth question is *concerning the connexion of the system.* Now of the nature and essence of the body or thing which is regarded as pure ether, and occupies the space between the stars, I will inquire afterwards. At present I will only speak of the coherence of the system. This may be in three ways. For there is either vacuum, or contiguity, or continuity; therefore we must first inquire, *whether there be a collective vacuum in the interstellar spaces?* a thing which Gilbert distinctly affirmed,[1] and which likewise some of those among the ancients who thought that the globes were dispersed without any system, seem to intimate; especially those who asserted that the bodies of the stars are compact. The opinion is this: that all the globes, as well the stars as the earth, consist of solid and dense matter: that these are immediately surrounded by a kind of bodies which are to a certain extent connatural with the globe itself, but yet more imperfect, languid, and attenuated; and are in fact nothing else than the effluvia and emanations of the globes themselves; such as vapours are, and exhalations, and indeed the air itself, when compared with the earth: that these emanations do not extend for any great distance round each globe; and that the remaining space (which is far the most extensive) is empty. Which opinion is countenanced by the fact that the bodies of the stars are seen at such an immense distance. For if all that space were filled, especially with bodies which are doubtless very unequal in density and rarity, the refraction of rays would be so great that they would not reach our sight; whereas if far the greatest part of that space be a vacuum, it is natural to suppose

[1] Gilbert, Physiol. Nova, i. 22.

that they traverse it more easily. And indeed this question will in great part depend on the question which I shall next bring forward concerning the substance of the stars, *whether it be dense, or rare and open.* For if their substance be solid, it will seem as if nature were only busy and anxious about the globes and their immediate neighbourhood; and that she leaves and passes by, as it were, the intermediate spaces. Therefore it would not be improbable that the globes are denser about the centre, more open towards the circumference, in the surrounding atmosphere and effluvia almost exhausted, and so terminated at last in vacuum. On the other hand, if the nature of the stars be rare and flamy, it will appear that the nature of rarity is not merely the diminution of density, but powerful and primary of itself, no less than the nature of solidity; and that it abounds both in the stars themselves, and in the ether, and in the air, so that there is no need of a collective vacuum. This question concerning a vacuum in the interstellar spaces will depend likewise on that question which relates to the principles of nature; *Does nature admit a vacuum?* Not however on this absolutely, without proper distinction. For it is one thing to deny a vacuum absolutely, another to deny a collective vacuum. For the reasons which may be advanced in favour of a vacuum interspersed, whereby bodies are relaxed and opened, are far stronger than those on which the assertion of a collective vacuum, that is, a vacuum extending over great spaces, is supported. And it was not Hero alone, a man of wit and a mechanician, who saw this, but Leucippus likewise and Democritus, the founders of the opinion concerning the vacuum, which Aristotle endeavours by cer-

tain fine reasons to attack and destroy; which two philosophers, certainly most acute and famous men, in admitting an interspersed vacuum, do in fact deny a collective one. For in the opinion of Democritus vacuity is bounded and circumscribed, so that beyond certain limits distraction or divulsion of bodies is no more possible than compulsion or compaction.[1] For although in those works of Democritus which have come down to us this is never expressly declared, yet he seems to imply as much when he asserts that bodies as well as spaces are infinite: using as his argument, that otherwise (that is, if space were infinite and bodies finite) bodies would never cohere. Therefore by reason of matter and space being equally infinite, vacuity is necessarily confined within certain bounds, which seems to have been his real opinion rightly understood; that is, that there is a certain limit to the expansion of bodies by reason of the vacuum with which they are coupled; and that there is no solitary vacuum, not enclosed in a body. But if there be no vacuum amounting to a solution of continuity in the system, yet as there is found so great a diversity of bodies in the parts and regions of the system that they seem to belong as it were to different nations and countries, there arises a second question, which relates to the connexion of the system; this is, *whether the pure ether be one perpetual and continuous fluid, or consist of many contiguous to one another?* Now it is not for me to refine about words, but by a contiguous body I understand a body which lies on another without mixing with it. I do not mean however a series of hard rigid floors, like the stories of a house, such as the vulgar

[1] Cf. Lucretius, i. 983.

astronomers imagine, but such a succession as fluids admit of, as when water floats on quicksilver, oil on water, air on oil. For no one can doubt but that in that immense tract of pure ether there are wonderful differences as to density and rarity and many other things; but upon either supposition (that is, whether you assume continuity or contiguity) this may be the case. For it is certain that even in the sea the water at the top and the water at the bottom are not of the same consistency and taste; while in the air, there is a very great difference between the air contiguous to the earth and the upper air; and yet the fluidity is one and entire and uninterrupted. The question therefore is brought to this, *whether the differences in the tract of pure air insinuate themselves gradually and with a continuous flow; or whether they take place at certain distinguishable limits, where the bodies which cannot mix are joined to each other; as with us air lies on water.* For indeed to a simple observer the whole of that pure and clear body in which the globes of the earth and stars float and hang as in an immense sea, and which is infinitely greater both in quantity and the space which it occupies than the globes between which it is interposed, seems to be a thing undivided and completely united. But to a deeper searcher of nature it will plainly appear that nature is accustomed to proceed for some distance by degrees, and then suddenly by jumps, and to take these processes in turn. Otherwise, if a man examine it well, no structure of things or organic figure could be formed, if the proceeding were always by imperceptible degrees. Therefore this gradual progress may do for the spaces between the worlds, but not for the world, the construction of which requires

that things very dissimilar be separated one from the other, and yet brought into approximation. Thus air succeeds to and touches earth and water, a body very different from them, and yet placed in immediate proximity; not first mud, then vapour or mist, and then pure air; but air at once, without any thing between. But in air and ether (for I put the two together) the most remarkable and radical division of all may be derived from a greater or less susceptibility of the starry nature. Between the globe of the earth then and the summits of heaven there seem to be generally three regions especially remarkable; namely, the tract of the air, the tract of the planetary heaven, and the tract of the starry heaven. Now in the lowest of these tracts, the starry nature is not consistent; in the middle it is consistent, but gathers into separate globes; in the highest it diffuses itself among a great number of globes, till at the summits thereof it seems to pass as it were into the perfect empyrean. But in the meantime I must not forget what I said just now, that nature is accustomed to adopt the gradual and the sudden process by turns, so that the confines of the first region communicate with the second, and the second with the third. For both in the higher air, when the air has begun to be cleared from the emanations of the earth and to be more rarefied by the emanations of the heavens, flame tries and endeavours to be consistent; as we see in the lower comets, which are of a middle nature between the starry nature in consistence and in evanescence; and again in the neighbourhood of the sun (it may be) where the heaven seems to become starry, and to begin to pass into the nature of the starry heaven. For it may be that those spots which have been discovered

in the sun, certainly by faithful and diligent observation, are a kind of rudiments of starry matter; whereas in the heaven of Jupiter absolute and perfect stars are discernible, though too small to be seen without the aid of telescopes; and again in the summits of the starry heaven it seems from the innumerable sparklings of the ether between the numbered stars (for which other causes bald enough are usually given) that the starry nature is more diffused and continuous. Of these things however I will speak further in the questions which I shall presently propose about the substance of the stars and the interstellar heaven. For the things which I have just said relate only to connexion of system. There remains the fifth question, *concerning the collocation of the parts of the system, or the order of the heavens.* And whether it be assumed that there is no system, but that the globes are scattered, or that there is a system, of which the sun is the centre; or even though astronomers look for some new system; yet there still remains the inquiry, *which planet is nearer to another planet, or further off;* and in like manner *which planet is more or less elongated from the earth or from the sun.* Now if the ancient system be received, there seems to be no reason why we should insist much upon a new inquiry concerning the four superior heavens, namely, the heavens of the fixed stars, of Saturn, of Jupiter, and of Mars. For with respect to their position and order the consent of ages is agreed, and there is no contrary phenomenon; the calculations of their motions also (whence is derived the chief proof of the heights of the heavens) are agreeable, and present no difficulty. But with regard to the Sun, Venus, Mercury, and the Moon, according

to the old system, the ancients were in doubt; and among the moderns also there is a question with regard to Venus and Mercury which of them is superior. For in favour of Venus being superior, there is the reason that she moves somewhat slower; and in favour of Mercury, that he is fixed at a less distance from the sun, whence one might assert that he ought to be placed next to the sun. But with regard to the moon, no one has ever doubted that she is placed nearest to the earth, though there are various opinions about her approximation to the sun. Nor should any one who is seriously considering the subject let another kind of question escape him, pertaining to the constitution of the system; that is, *whether one planet sometimes goes above another and sometimes again comes below;* a thing which seems to be proved with regard to Venus by some tolerably diligent demonstrations, that she is found sometimes above and sometimes below the sun. It is a very fit inquiry also, *whether the apogee of the lower planet does not cut the perigee of the higher and enter its boundaries.* There remains the last question, *concerning the position of the parts of the system;* that is, *whether there be many different centres in the system, and as it were many dances;* especially as not only the earth is set down as the centre of the *primum mobile*, and the sun (according to Tycho) of the *secundum mobile;* but Jupiter likewise is supposed by Galileo to be the centre of those smaller and recently discovered wanderers. Such then are these five questions, which seem fit to be proposed concerning the system itself, namely, *is there a system? what is the centre of it? what the depth? what the connexion? and what the order of the position of the parts?*

As for the extremities of the heaven and the empyrean, I do not draw up any propositions or questions concerning them. For there is no history of these things nor any phenomenon extant. And therefore what can be known about them can only be known by consequence, and not at all by induction. For such inquiry however there will come a fit time, and a plan and method. But with regard to the immateriate heavens and spaces, we must rest entirely upon religion, and leave them to it. For as for what the Platonists and of late Patricius (by way of giving their philosophy a diviner character) have alleged, not without superstition, arrogance, and some disorder of mind, and in a word, with too much presumption and no fruit, like the images and dreams of Valentinus; I regard all such things as idle fancies. For an apotheosis of Folly, like that of the Emperor Claudius, is a thing not to be endured; and most mischievous it is, and a very pest and destruction of the understanding, for vanity to be made an object of veneration.

CHAP. VII.

Then follow questions concerning the substance of heavenly bodies; namely, what is the substance of heavenly bodies generally as compared with sublunary bodies; what is the substance of the interstellar ether as compared with the body of a star; what is the substance of the stars as compared with one another, with our fire, and in their own nature; what is the substance of the Milky Way, and the black

spots in the antarctic hemisphere? *Then is proposed the first question*, Is there a heterogeneity between celestial and sublunary bodies, and of what nature may it be?

HAVING finished the questions concerning the system, we must proceed to those concerning the substance of the heavenly bodies. For the inquiry concerning substance of the heavenly bodies and the causes of their motion, belongs principally to philosophy; the inquiry concerning the motion itself and the accidents thereof, to astronomy; the inquiry concerning their influence and power, to both. Now it ought to have been so arranged between astronomy and philosophy, that astronomy should prefer those hypotheses which are most convenient for compendious calculations; philosophy those which come nearest to the truth of nature. And further, that while the hypotheses adopted by astronomy for convenience should by no means prejudice the truth of the thing, the judgments of philosophy in their turn should be such as are perfectly reconcileable with the phenomena of astronomy. But now it comes to pass contrariwise, that the fictions of astronomy have been introduced into philosophy and corrupted it; while the speculations of philosophers about the celestial bodies please none but themselves, and almost forsake astronomy, looking at the celestial regions in general, but not at all addressing themselves to particular phenomena and their causes. Therefore since both sciences (as now practised) are slight and superficial, we must plant our footing deeper; and treat these two, which by reason of the narrowness of men's views and the practice of professors have been for so many ages separated, as one and the same thing, and making up

together one body of science. The first question proposed therefore is, *whether the substance of the heavenly bodies is different in kind from the substance of those below?* For Aristotle's temerity and cavilling has begotten for us a fantastic heaven, composed of a fifth essence, free from change, and free likewise from heat.[1] Now to say nothing at present about the four elements, which this fifth essence supposes, it was certainly an act of great boldness to destroy altogether the relationship between the elementary, as they call them, and the celestial bodies; seeing two of the elements, namely air and fire, agree so well with the stars and ether; only that it was his way to abuse his wit, and make difficulties for himself, and prefer those things which were more obscure. Yet there is no doubt that the regions above and below the moon, together with the bodies contained in the same space, differ in many important points; but then again there is as little doubt that the bodies of both regions have many common inclinations, passions, and motions; so that, with due regard to the unity of nature, we should rather distinguish these than separate them. But as for that point of heterogeneity, that the heavenly bodies should be supposed eternal, the inferior corruptible; the opinion seems to fail both ways, for neither does such eternity as they feign belong to the heaven, nor such mutability to the earth. For with respect to the earth, if the matter be truly considered, judgment is not to be made from the things which are visible to us, since among the bodies seen by man's eye there is none that has been disinterred or cast up from a depth of above three miles at the most, which is as nothing compared

[1] Arist. de Cœlo, ii. 7.

with the extent of the whole terrestrial globe. Therefore there is no reason for thinking that the interior of the earth is not endowed with the same eternity as the heaven itself. For if the earth underwent changes in its inmost depths, it could not be but that the consequences of those changes would produce, even in this region where we tread, greater accidents than we see take place. For of the changes visible to us here towards the surface of the earth, there appears almost always some manifest cause sent from above, due to the state of the atmosphere, to rains, heats, and the like; so that the earth itself, of its own proper force, does not seem to cause any considerable change. And if it be granted (which certainly is probable) that the earth itself also, as well as the heavenly bodies, acts upon the regions of the air, either by exhaling cold, or by emitting winds, or the like; yet all that variety may be referred to the parts of the earth close at hand, in which no man in his senses would deny that very many changes and alterations take place. It must certainly be confessed that of all terrestrial phenomena, those which penetrate deepest into the earth are earthquakes and things of that sort, as eruptions of water, vomitings of flames, yawnings and rents of the earth, and the like; yet even these seem to rise from no great distance, seeing most of them occupy only a small space in the surface of the earth. For the wider the space an earthquake or anything of that kind extends on the surface of the earth, the deeper must we suppose its roots and sources to penetrate into the interior; and the narrower the less deep. And if it be said that there are sometimes earthquakes which shake vast and extensive districts of country, so no doubt it is. But

these certainly happen seldom, and are to be numbered among the greater accidents; and may be compared therefore with the higher comets, which are also uncommon. For I am not attempting to prove simply that the earth is eternal, but only (as I said at first) that between heaven and earth, as regards constancy and change, there is not much difference. Neither is it worth while to reason of eternity from the principles of motion; for as circular motion may be without limits, so may rest; and the consistency of dense bodies in the place and great congregation of their connaturals is not less susceptible of eternity than the rotation of rare bodies; seeing that the parts of both when separated from the rest move in a straight line. That the interior of the earth is not more subject to corruption than the heaven itself, may be inferred also from this, that waste commonly takes place where there are means of supply. Now as rains and things falling from above, which renew the surface of the earth, cannot penetrate far into the interior, which nevertheless remains undiminished in bulk and quantity, it must be that nothing is lost, since there is nothing to take its place. Lastly, the mutability which is discovered in the exterior of the earth seems itself to be by accident. For that small incrustation which seems to extend a few miles downwards (within which those noble workshops and fabrics of plants and minerals are enclosed) would scarce receive any variety, much less such beautiful and elaborate contrivances, unless that part of the earth were acted upon and perpetually stimulated by the heavenly bodies. And if any one think that the heat and active power of the sun and heavenly bodies can strike through the thickness of the whole earth, he

may be regarded as superstitious and fanatical; seeing it is very evident by how small an obstacle they may be repelled and restrained. So much then for the constancy of the earth; we must now inquire concerning the mutability of the heavens.

First then we are not to infer that changes in the heavens do not take place because they are not visible to us. For the sight is disabled both by distance of place, and by excess or deficiency of light, and by the fineness or smallness of the body; and if a man were to look from the moon he would not be able to see the changes which take place here with us on the surface of the earth, such as inundations, earthquakes, buildings, structures, and the like; which would not show so big as little straws at so great a distance. Nor from the fact that the interstellar heaven is transparent, and in clear nights the stars are seen the same in number and appearance, can a man conclude that the whole body of ether is clear, pure, and immutable. For we know that the air below admits innumerable varieties of heat, cold, odours, and all kinds of mixture with the finer vapours, and does not thereby lose its transparency; in like manner therefore we must not trust to the face or appearance of the heaven. For if those great masses of clouds which sometimes obscure the heaven, and by reason of their proximity to our view take away from us the light of the sun and stars, were hung in the higher parts of the heaven, they would no way alter the face of a clear sky; since they would neither be visible themselves by reason of the distance, nor would they at all eclipse the stars, by reason of the smallness of their bodies, in respect to the magnitude of the stars. Nay the body of the moon itself, except in the part

which the light strikes, does not change the appearance of the sky; so that, if that light were absent, so great a body as that would be altogether imperceptible to us. On the other hand it is quite plain from the masses of bodies which by their bulk and magnitude can overcome the distance of space, and by the luminous nature and brilliancy of their matter can affect our sight, that wonderful changes and unusual appearances do happen in the heaven. For this is shown in the higher comets, those I mean which have appeared in the figure of a star without a tail, and are not only proved from the doctrine of parallax to be situated above the moon, but have likewise had a certain and constant position relative to the fixed stars, and kept their places, and not been wanderers; such as our age has witnessed more than once, first in Cassiopea, and again not so long ago in Ophiuchus. And as for the notion that this constancy visible in comets proceeds from their following some star (which was the opinion of Aristotle, who affirmed that there was the same relation between a comet and a single star as between the milky way and the collection of stars, an assertion false both ways), this has long ago been exploded, not without a censure on the wit of Aristotle, who ventured to invent such theories on slight grounds.[1] Neither does that change in the celestial regions with regard to new stars hold with regard to those stars only which seem to be of an evanescent nature, but likewise in those which remain. For in the case of the new star of Hipparchus, mention is made by the ancients of the appearance of it,[2] but no mention of the disappearance. There appeared also of late a new star in the breast of Cygnus, which has now

[1] Cf. Arist. Meteorol. i. 8.

[2] Cf. Pliny, ii. 23.

lasted for twelve whole years, having already exceeded the age (as it is held) of a comet, without as yet any diminution or preparation for flight. Nor again can it be affirmed as a fact without exception that the old stars suffer no change at all, but only those that have appeared more recently; in which it is no wonder that a change should take place, seeing their very generation and origin is not immemorial. For setting aside the fable of the Arcadians about the first appearance of the moon, which they assert to be younger than themselves,[1] there are not wanting examples within trustworthy memory, when the sun on three several occasions, without eclipse or interposition of clouds, the air being clear and serene, appeared for many days with an altered visage; yet not affected in the same manner each time, but once faint, and twice of a reddish brown. For such phenomena happened in the year 790 for seventeen days, and in the times of Justinian for half a year, and after the death of Julius Cæsar for several days. Of the Julian darkness there remains that notable testimony of Virgil: —

> Ille etiam extincto miseratus Cæsare Romam,
> Cum caput obscurâ nitidum ferrugine texit,
> Impiaque æternam timuerunt secula noctem.[2]

The narrative of Varro, a man most learned in antiquity, respecting the star Venus, which is found in Augustine,[3] — namely, that in the time of King Ogyges she changed colour, size, and shape, — might have been of doubtful credit, had not a like event recurred in our

[1] Cf. Ovid, Fasti, i. 469.

[2] Georg. i. 469.: —

> Then did the sun in pity dim his light,
> And drew a dusk veil o'er his visage bright,
> And shook the impious times with dread of endless night.

[3] St. August. De Civit. Dei, xxi. 8.

age, in the year 1578, and attracted much notice. For then also through a whole year a remarkable alteration took place in the star Venus, which appeared of unusual magnitude and brilliancy, and redder than Mars himself, and changed her shape several times, becoming sometimes triangular, sometimes quadrangular, and even sometimes round, as if her very mass and substance were affected. Again, that old star in the hip of Canicula, which Aristotle says that he himself saw with somewhat of a tail, and that tail, especially when cursorily looked at, vibrating, seems now to be changed and to have lost its tail; since nothing of the kind can now in our time be detected.[1] Besides, many changes of heavenly bodies, especially in the smaller stars, may easily from neglect of observation pass unnoticed, and be lost to us. That these things are due to vapours and the disposition of the medium will occur at once to any sciolist; but changes which are found to attend the body of any star constantly, equably, and for a long continuance, and to revolve along with it, must be regarded as being in the star itself, or at least in the ether near it, not in the lower regions of the air; which is likewise confirmed by the fact, that such changes take place seldom, and at long intervals; whereas those which are caused in the air by the interposition of vapours take place more frequently. And if any man concludes from the order of the heaven and the equability of the motion itself that the heaven is immutable; taking this certainty of revolutions and restitutions for a sure token of eternity, inasmuch as constancy of motion can hardly belong to a corruptible substance; he should look about him a little more attentively, and ob-

[1] Arist. Meteorol. i. 6.

serve that this return of things by turns and as it were in circle at fixed times, is found even with us here below in some things; most of all in the tide of the ocean; while those smaller differences which may take place in the heavens both in the revolutions and restitutions escape our sight and reckoning. No more again can the circular motion of the heaven be taken as a proof of eternity; on the ground that circular motion has no limit,[1] and eternal motion belongs to eternal substance. For the lower comets that are situated below the moon revolve likewise, and that of their own force; unless you had rather believe the fiction of their being attached to a star. And assuredly if we argue of the eternity of the heavenly bodies from their circular motion, we must apply the argument to the whole heaven, and not to parts of it; for we know that the air, sea, earth, though eternal in their masses, are perishable in their parts. But it may rather be said, contrariwise, that this argument from the motion of rotation does not tell in favour of the eternity of the heaven; because this motion itself is not perfect in the heaven, and does not restore itself exactly in a pure and perfect circle, but with deviations, curves, and spirals. If again a man retort upon me that which I said concerning the earth (namely, that the changes which take place in it happen by accident, because the earth is acted on by the heaven), and assert that the case of the heaven is different, seeing that the heaven cannot in any way be acted upon in its turn by the earth, inasmuch as all emanation from the earth stops on this side of the heaven, and therefore it is probable that the heaven, being set apart beyond the reach of any hostile force,

[1] Arist. De Cœlo, i. 9.

is susceptible of eternity, not being disturbed or shaken by an opposite nature; his objection is not to be despised. For I have no respect for the simple notion of Thales, who thought that the celestial fires fed on the clarified vapours of the earth and ocean, and were thence nourished and repaired;[1] (whereas these vapours fall back again in almost the same quantity as they rose, and are far from being enough to refresh both the earth and the celestial globes, nor can they at all mount so high;) but yet admitting that these materiate emanations of the earth stop far below the heaven, nevertheless if the earth be, as Parmenides and Telesius supposed, the original source of cold, it is not easy to say for certain to what height this opposite and rival power to the heaven may insinuate itself by series and succession; especially as rare bodies imbibe the nature and impression of heat and cold, and transmit it to a great distance. Grant however that the heaven is not acted upon by the earth, why may not celestial bodies be affected and changed one by another, — the sun by the stars, the stars by the sun, the planets by both, and all by the ambient ether, especially at the borders of their globes? Then again the opinion of the eternity of the heaven derives much apparent strength from the very machinery and construction of the heaven, about which astronomers have taken such pains. For great provision seems to be made thereby to exempt the celestial bodies from all change besides simple rotation, and leave them in other respects at rest and without perturbation. Therefore they have supposed the bodies of the stars to be fixed in their orbs, as if they were nailed; while to each of

[1] Plutarch, De Placit. Philosoph. i. 3.

their declinations, elevations, depressions, and sinuous movements they have assigned so many perfect circles of suitable width; carefully turning and smoothing both the concave and the convex parts of those circles, so as to leave no prominence or roughness, but that one may fit into another, and, being by reason of the polish at once exactly contiguous and free to slide easily, may move quietly and happily; which immortal contrivance removes all violence and perturbation, the inseparable forerunners of corruption. For certainly if such great bodies as the globes of stars are do pass through ether, and yet do not always travel through the same parts of it, but through parts and tracts very different, sometimes invading the higher regions, sometimes descending to the lower, sometimes turning to the south, sometimes to the north, there is danger no doubt of very many impressions, concussions, reciprocations, and fluctuations in the heaven, and that hence may ensue condensations and rarefactions of bodies, which may procure and prepare the way to generations and alterations. But since it will clearly appear from physical reasons, and withal from the phenomena themselves, that this last is really the fact; and those figments of astronomers of which I spoke are, as any man of sound judgment will see, mere mockeries of nature, without any reality in them; it is but reasonable that the opinion of the eternity of the heaven, connected as it is with them, should undergo the same judgment. And if objection be here made on religious grounds, I answer that it is only heathen arrogance that attributes this eternity to the heaven alone; sacred writ assigns eternity to earth and heaven alike. For we read not only that "the Sun and Moon are eternal and faithful

witnesses in the heaven," but also that "Generations come and go, but the Earth remaineth for ever." [1] And for the transitory and perishable nature of both, we find it concluded in one oracle, "Heaven and earth shall pass away, but the Word of the Lord shall not pass away." [2] Again, if it be still urged that for all this it must be admitted that there are innumerable changes in the surface of the earth and the parts next to it, whereas it is not so in the heaven; I reply that in the first place I do not maintain them to be in all respects alike; and yet that if we take what are called the upper and middle regions of the air for the surface or inner covering of the heaven, as we take that space with us in which animals, plants, and minerals are contained, for the surface or outer covering of the earth, various and multiform generations are found there likewise. It would seem therefore that all tumult, conflict, and disorder take place only in the confines of heaven and earth; just as it is in civil matters, in which it is commonly found that the border land of two kingdoms is troubled by continual inroads and violence, while the interior provinces of both countries are in the enjoyment of long peace, and are not disturbed except by the more serious wars, which happen rarely. As for that other point of heterogeneity in the celestial bodies (as asserted by Aristotle [3]), that they are not hot in themselves (for otherwise the conflagration of Heraclitus might ensue), but only the cause of heat by accident, through the friction and diverberation of the air; I know not what a man can mean who abandons experience in this way, and that too against the consent of the ancients. But it is nothing new in him to snatch

[1] Ecclesiastes, i. 4. [2] St. Matth. xxiv. 35. [3] Aristot. De Cœlo, ii.

some one thing from experience, and straightway proceed to trample on nature, joining pusillanimity with audacity. Of this however I shall speak presently upon the question, *whether the stars are real fires;* and more fully and accurately in my precepts concerning the history of Virtues, where I shall treat of the origins and cradles of Heat and Cold, a subject hitherto unknown and untouched by men. Let the question then of the heterogeneity of the celestial bodies be propounded in this manner; for though the case calls perhaps for judgment against the opinion of Aristotle without adjournment, yet my plan of proceeding does not allow of it.

Another question is, *what is contained in the interstellar spaces?* For they are either empty, as Gilbert thought; or filled with a body which is to the stars what air is to flame, — a supposition which comes familiarly to the sense; or filled with a body homogeneous with the stars themselves, lucid and almost empyreal, but in a less degree, that is with a light not so refulgent and flashing, — which seems to be the meaning of the received opinion,[1] that a star is the denser part of its sphere. Nor is there any reason why a lucid body should not be a transparent medium for the transmission of a stronger light. For Telesius has acutely remarked that even common air contains some light, using as an argument that there are some animals which see by night, their sight being (it would seem) adapted to receive and cherish this feeble light:[2] for that it is not credible that the action of light can take place without any light, or merely by the internal light itself of the visual spirit. But we see that flame

[1] Aristot. De Cœlo, ii. 7.

[2] Telesius, De Rer. Nat. i. 3.

itself is a transparent medium for the transmission even of the species of an opaque body, as is shown in the wick of a candle; much more of the species of an intenser light. Of flames likewise some are more pellucid than others. And this is caused either by the nature of the lighted body or the quantity. For the flame of tallow or wax is more luminous and (so to speak) more fiery; whereas the flame of spirit of wine is more opaque, and as it were airy, especially if it be in a small quantity, so that the flame does not thicken itself. Of this I have myself made trial. For I took a wax candle and set it upright in a socket (making use of a metal one for the purpose, that the body of the candle might be protected against the flame by which it was to be surrounded); and having placed the socket in a porringer where there was a little spirit of wine, I lighted first the candle, and then the spirit of wine; when it was easy to see the flame of the candle coruscating and white, through the middle of the flame of the spirit of wine, which was weak and inclining to transparency. And in like manner lucid beams are often seen along the heaven, emitting a manifest light, and wonderfully illuminating the darkness of the night; through the borders of which nevertheless the stars are visible. This inequality however between the stars and interstellar ether is not well defined by rarity and density; as if the star were denser, the ether rarer. For in general here with us flame is a body more subtle than air, — more expansive, I say, and having less matter in proportion to the space it occupies; and it is probable that this is the case also in the heavens. But the error is more harsh, if they mean that the star is a portion of the sphere fixed as with a nail, and the ether

that which carries the star. For this is a fiction, like that series of orbs ranged one above another which is described. For either the body of star passes through the body of the ether in its course, or else the ether itself revolves at the same time with an equal motion. For if the motion be not equal, in that case also must the star pass through the ether. And as for that structure of contiguous circles, whereby the concave part of the outer admits the convex of the inner, and yet by reason of the smoothness of both the one does not obstruct the other in its rotations, though they are unequal, — it is not a reality; the body of ether being uninterrupted and continuous, as that of the air is; although, there being so great difference between the two as regards rarity and other things, their regions are for convenience of explanation very properly distinguished. Let this question therefore be admitted, as I have thus explained it. Next comes another question, and that likewise not a simple one; concerning the substance of the stars themselves. For it is asked first, *whether there be other globes or masses of solid and compact matter besides the earth itself?* For it is a speculation soberly proposed in a book concerning the face in the moon's orb, that it is not probable that in the dispersion of matter nature included all compact body in the globe of the earth alone, when there is so great an array of globes composed of rare and expansive matter.[1] But Gilbert carried the same idea so immoderately far (wherein however he had some of the ancients as precursors, or rather guides), as to assert that not only the earth and moon, but likewise many other globes, solid and opaque, are scattered

[1] Plutarch, De Facie in Orbe Lunæ, p. 924.

among the shining globes throughout the expanse of heaven.[1] Neither did his opinion stop here, but he thought likewise that those globes which are shining in appearance, namely, the sun and the brightest stars, consisted of a kind of solid matter, though more splendid and equal; confusing primitive light with luminous matter, which is regarded as its image (for he thought that even our sea throws out light of its own for a proportionate distance); but he acknowledged no conglobation, except in solid matter; of which matter he held those rare and fine bodies that surround it to be a kind of effluvia, and as it were defections; and beyond them a vacuum. Now that the moon is composed of solid matter is a thought which might occur to the most diligent and sober investigator of nature. For it reflects light, it does not transmit light, it is without any proper light of its own, and it is full of inequality; which are all properties of solid bodies. For we see that the ether itself and the air, which are rare bodies, receive the sun's light, but do not reflect it; which the moon does. The sun's rays are so vigorous that they can penetrate and pass through very thick clouds, which are of a watery matter; but they cannot pass through the moon. The moon itself in some eclipses gives some degree of light, though obscure; but in new moons and the quarters no light at all is visible except in the part which is touched by the sun's rays. Moreover, though it be true that impure and feculent flames (of which kind of substance Empedocles[2] thought the moon consisted) are unequal, yet the inequalities have no fixed places, but are commonly movable; whereas the spots in the moon are supposed

[1] Gilbert, Physiol. Nov. ii. 10. [2] Stobæus, Eclog. Phys. i. 27.

to be constant. Besides, it is now ascertained by telescopes that these spots also have their own inequalities, so that the moon is found to be clearly of manifold configuration, and that selenography or map of the moon, which Gilbert conceived, seems now by the industry of Galileo and others to be nearly attained. But if it may be that the moon is made of a certain solid matter, as being kindred to the earth, or the dregs of heaven (and such things are talked of), we must next inquire whether it be the only one of this kind. For Mercury too is sometimes found in conjunction with the sun, like a spot or little eclipse. But those dusky spots which are observed in the antarctic hemisphere, and which are fixed, like the milky way, suggest a greater doubt concerning the existence of opaque globes in the higher parts of the heaven. For that they are caused by the heaven in those places being rare and as it were perforated, is not probable; because such a diminution and as it were privation of a visible object could not affect our sight at so great a distance; since the rest of the body of ether is itself invisible, and can only be distinguished by comparison with the bodies of stars. It would perhaps be more probable to attribute these blacknesses to defect of light, because the stars are fewer in that part of the heaven, as on the other hand in the neighbourhood of the milky way they are more crowded; so that the one place would seem to be continuously luminous, the other interspersed with shadows. For the celestial fires appear to be more joined together in the antarctic hemisphere than in ours; there being larger stars there, but not so many, and greater spaces between. But the report itself concerning those spots is not much to be relied on; at

least there has not been enough diligence used in the observation to justify us as yet in drawing any consequences therefrom. A fact which touches the present inquiry nearer is, that there may possibly be other opaque bodies scattered through the ether, which are not seen at all. For the moon herself when new, though the horn and thin rim of the outer circle, as far as the sun's rays touch, strike the sight, is not visible at all in the middle of the disc: that part is not distinguishable in appearance from the rest of the ether; and those wandering stars discovered (if the report may be trusted) about Jupiter by Galileo are lost to our sight in that sea of ether, like so many small and invisible islands; and in like manner also those stars whereof the collection makes the milky way, if they were placed each apart, and not assembled in a crowd, would escape our sight altogether; as likewise many others, that in clear nights, especially in winter, sparkle; besides, those nebulous stars are openings in *Præsepe* are now resolved by telescopes into a number of distinct stars; nay, and it seems that in the very purest fountain of light (I mean the sun), there is some reason, on the evidence of these same telescopes, to suspect the existence of spots, opacity, and inequalities. But if there were no other evidence, the very gradation of light among the celestial stars, descending as it does from the most brilliant to those which are obscure and misty, is enough to prove that there may likewise be globes which are completely opaque. For there seems less difference between a nebulous and opaque star than between the brightest star and a nebulous one. But our sight is plainly deceived and circumscribed; for whatever is dispersed in the heaven, and

has not great magnitude and likewise a strong and vivid light, is concealed from us, and does not alter the face of the heaven. And let not any unskilful person be astonished if it be made a question whether globes of compact matter can remain pendulous. For both the earth itself floats pendulous in the middle of the surrounding air, which is an exceedingly soft thing; and great masses of watery clouds and stores of hail hang in the regions of the air, whence they are rather forced down than fall of themselves, before they begin to feel the neighbourhood of the earth. Excellently therefore did Gilbert remark, that heavy bodies when removed to a great distance from the earth gradually lose their motion downwards; inasmuch as that motion rises from no other appetite of bodies than that of uniting and collecting themselves to the earth (which is the mass of bodies of the same nature with them), and is confined within the orb of its own virtue.[1] For as for what is said of motion to the earth's centre, it would indeed be a potent kind of Nothing that should draw such great things to it; nor is body acted on except by body. Therefore let this question concerning solid and opaque globes, though new and harsh to vulgar opinions, be admitted; and let there be joined with it the old though still unsettled question, *which of the stars emit a primitive light, and from themselves, and which a light derived from the sun?* whereof the one seem to be consubstantial with the sun, the other with the moon. And in short, all inquiry concerning the different substance of the stars as compared one with the other, which appears to be multifarious, some stars looking fiery, others lead-coloured, others white, others

[1] Gilbert, Physiol. Nova, i. 21.

brilliant, others manifestly and constantly nebulous, I mean to be referred to this seventh question. Another question is, *are the stars true fires?* a question however which requires some care to understand it rightly. For it is one thing to say, that *the stars are true fires;* and another thing to say that *the stars (admitting them to be true fires) exert all the powers and produce the same effects which common fire does.* Nor does this require us to suppose some notional or imaginary fire, retaining the name of fire without its properties. For our fire also, if it were placed in the ether in such a quantity as the stars are, would perform different operations to those which it does here with us; seeing things acquire very different virtues, both from quantity and from relative position or location. For the greater masses, I mean connatural bodies which are collected in such quantity as to bear a due proportion to the sum of the universe, assume cosmical virtues, which are not to be found in the portions of them. Thus the ocean, which is the largest collection of waters, ebbs and flows; whereas pools and lakes do not. In like manner the whole earth hangs suspended; a piece of earth falls. And the relative position of a thing is of great importance in all respects both in the larger and smaller parts, by reason of the contiguity and neighbourhood of friendly or unfriendly bodies. But there must also be a far greater diversity of actions between the fire of the stars and our own, because it varies not only in quantity and relative position, but also to some extent in substance. For the fire of the stars is pure, perfect, and native; whereas our fire is degenerate, like Vulcan thrown from heaven and halting with the fall. For if a man observe it, fire as we have it here is out of

its place, trembling, surrounded by contraries, needy, depending for sustenance upon fuel, and fugitive. Whereas in heaven fire exists in its true place, removed from the assault of any contrary body, constant, sustained by itself and things like itself, and performing its proper operations freely and without molestation. And therefore Patricius had no need, in order to preserve the pyramidal form of flame, as it is found with us, to fancy that the upper part of a star, which is turned towards the ether, may be pyramidal, though the lower, which is visible to us, be globular. For that pyramid of flame comes by accident, from the air closing in and crushing it; since the flame, which is fuller in the region of its aliment, is by the hostility of the air insensibly contracted and moulded into the form of a pyramid. Hence flame is broad at the base and pointed at the apex, smoke on the other hand is pointed at the bottom and broad at the apex, and like a pyramid inverted; because the air receives smoke, but quenches flame. It is natural therefore that flame should with us be pyramidal, and in the heaven globular. In like manner also flame with us is a momentary body, in ether permanent and durable. And yet even with us flame might last and subsist in its own form, if it were not destroyed by the things about it; which is most manifest in the larger flames. For all that part of a flame, which is situated in the midst and surrounded by flame on all sides, perishes not, but remains the same in quantity unextinguished and rising rapidly upwards; whereas at the sides it is troubled, and it is there that extinction commences. The manner whereof (I mean the permanency of the inner flame in a globular figure, and the vanishing and pyramidal

form of the outer flame) may be experimentally demonstrated by using flames of two colours. Then again in point of fierceness there may be a great deal of variation between the celestial flame and ours. For the celestial flame unfolds itself freely and calmly, as being at home, whereas our flame, as being a stranger, is pent in and violent and furious. All fire likewise when close packed and imprisoned becomes fiercer. For the rays of celestial flame themselves when they reach the denser and more obstinate bodies, lay aside their gentleness, and become more scorching. Aristotle ought not therefore to have feared the conflagration of Heraclitus for his world, although he had determined the stars to be real fires. This question then may be received according to this explanation. Next comes another question ; *whether the stars are nourished*, and likewise, *whether they are increased, diminished, generated, and extinguished.* There was one of the ancients indeed who with a plebeian kind of observation thought that the stars are nourished as fire is, and that they feed on the waters and ocean and moisture of the earth, and are repaired by vapours and exhalations. But this opinion does not seem worthy to supply matter for a question. For such vapours are both exhausted long before they reach the heights of the stars, nor is there enough of them to repair the waters and the earth with rains and dews, and withal to refresh so many and great celestial globes ; especially as it is evident that the earth and ocean have continued now for many ages without decrease of moisture ; whereby it seems that no more is drawn out than comes back again. Nor again does the principle of aliment apply to the stars as it does to our fire. For the principle is that

wherever anything perishes and departs there likewise something is replaced and assimilated; which kind of assimilation belongs to the region of confusions, and comes of being surrounded by contrary or dissimilar bodies; whereas in the similar and inner mass of the stars nothing of the kind happens, no more than in the bowels of the earth, which themselves also receive no nourishment, but preserve their substance in its identity, not by assimilation. With regard however to the outer borders of the sidereal bodies, the question is rightly asked, *whether these remain of one and the same tenor, or whether they prey on the surrounding ether, and likewise infect it?* In this sense therefore a question may be put concerning the aliments of the stars. And to this is rightly joined a question as to the augmentations and diminutions of stars in their whole; though the phenomena are very few which can give occasion to this doubt. For in the first place there is no example of the thing, nor anything resembling it among the things found with us, to countenance such a question; seeing that our globe of earth and water does not seem to be liable to any evident or notable augmentation or diminution on the whole, but to preserve its mass and quantity. But the stars (it will be said) appear to our eyes sometimes of a greater, sometimes of a smaller body. True; but that greatness and smallness of a star is due either to distance and vicinity, as in the apogees and perigees of planets, or to the constitution of the medium. Now that which is caused by the constitution of the medium is easily distinguished, because it changes the appearance, not of some one particular star, but of all alike; as we see in winter nights, in hard frost, when the stars appear

increased in magnitude, because vapours both rise more sparingly and are harder strained, and the whole body of the air is somewhat condensed, and inclines to the aqueous or crystalline, which shows forms more large. And if there chance to be any particular interposition of vapours between our sight and one particular star, which magnifies its apparent size (as is frequently and manifestly the case with the sun and moon, and may happen with the rest), neither can this appearance deceive; because this change of magnitude does not last, nor does it follow the star or move with the body of it, but the star is soon freed from it and recovers its usual appearance. Nevertheless although these things be so, yet since both formerly in ancient times and likewise in our own age — when it was a great sight and much talked of — a great change took place in the star of Venus both as to magnitude and colour, and even shape; and since a change which perpetually and constantly follows one particular star, and is seen to revolve along with it, must necessarily be set down as being in the star and not in the medium; and since through neglect of observation many things that are conspicuous in the heavens are passed by and lost to us; I think that this part of the ninth question is rightly admitted. The other part of the question is of the same kind; *whether stars are in long revolutions of ages created and dissipated?* There is a greater number of phenomena indeed to challenge this question than that about their augmentations and diminutions; but yet only of one kind. For as to the old stars, neither have we in all the memory of ages any record of the first birth of any of them (except the stories which the Arcadians of old

told about the moon), nor is one of them missing. Of those however which have been regarded as comets, yet having the form and motion of stars, and being exactly like new stars, we have witnessed both appearances (of which we have likewise heard from the ancients) and disappearances; when they looked to some persons as if consumed, to some as if taken up (that is, as if having come down to us in their perigees, they returned again to the higher regions), to others as if rarefying and dissolving into ether. But all this question concerning new stars I refer to that place where I shall speak of comets. There remains another question, namely concerning the milky way; *is the milky way a collection of small stars, or a continuous body, and part of the ether, of a middle nature between the ethereal and the starry?* For that opinion concerning exhalations has itself long ago exhaled, not without censure of the wit of Aristotle, who ventured to invent such a matter,[1] ascribing to a thing so constant and fixed a nature transitory and variable. And this question moreover, as I put it, seems on the point of being settled, if we believe the report of Galileo, who has resolved this confused appearance of light into stars numbered and placed. For the fact that the milky way does not hide from view those stars which are found within it, certainly does not settle the question, nor incline the balance either way. Only perhaps it proves by way of negation that the milky way is not situated below the starry heaven. For if it were, and if withal that continuous body of the milky way had any depth, our view would probably be intercepted. But if it be situated at the same altitude as the stars

[1] Arist. Meteor. i. 8.

which are seen through it, why may not stars be scattered in the milky way itself, as well as in the rest of the ether? This question therefore I admit likewise. And these six questions pertain to the substance of the heavenly bodies; namely, what is the substance of the heaven in kind, what that of the interstellar ether, what that of the milky way, and what that of the stars themselves, compared either with one another, or with our fire, or with their own body. As to the number, magnitude, configuration, and distance of the stars, besides the phenomena themselves and historical questions, of which I shall speak afterwards, the philosophical problems are mostly simple. With regard to the number there follows this other question; *is the number of the stars that which appears, and which has been observed and set down by the diligence of Hipparchus, and included in his model of the celestial globe?* For not only is that a poor reason that is given for the countless multitude of hidden stars not distinctly visible, which is usually seen in clear nights, especially during the winter; namely that these appearances are not smaller stars, but only radiations and flashings and as it were darts cast from the known stars; but the census now made by Galileo of the celestial population contains additional heads, not only in that cluster denominated the milky way, but likewise among the very stations and ranks of the planets. And stars become invisible, either by reason of smallness of body, or by reason of opacity (for I do not much approve of the term "tenuity," seeing that pure flame is a body of extreme tenuity), or by reason of elongation and distance. As for the question respecting the increase of the number of the stars by the generation of new

ones, I refer it as before to the place where I shall speak of comets. Now with regard to the magnitude of the stars, the apparent magnitude belongs to phenomena, but the true magnitude to philosophical inquiry, within the limits of that twelfth problem; *what is the true magnitude of each star, either measured, or at least compared?* for it is easier to discover and prove that the globe of the moon is smaller than the globe of the earth, than that the globe of the moon is so many miles in circumference. We must therefore find exact magnitudes, if we can; and if they cannot be had, we must make use of comparative. Now true magnitudes are taken and concluded either by eclipses and shadows; or by extensions as well of light as of other virtues which each body shoots out and diffuses to a greater or less distance in proportion to its magnitude; or lastly by the symmetry of the universe, which by a kind of necessity governs and defines the portions of connatural bodies. We are not however to be bound by the statements of astronomers regarding the true magnitudes of stars; statements made (though it may seem a matter of great accuracy and subtlety) loosely and carelessly enough; but we must seek proofs (if there be any) more trustworthy and genuine. Now the magnitude and the distance of the stars mutually indicate each other from optical calculations; which themselves however require sifting. This question then concerning the true magnitude of the stars is the twelfth in number. Next comes another concerning their figure; *whether the stars are globes;* that is collections of matter in a solid round figure? To appearance there seem to be three figures of heavenly bodies; globular and beamy like the sun,

globular and angular like the stars (the beams and angles referring only to sight, the globular form only to substance); globular simply, like the moon. For there is no star to be seen which is oblong or triangular or square, or of any other figure. And it seems natural that the greater masses of things should for their preservation and more perfect union collect into globes. The fourteenth question relates to distance; *what is the true distance of any star in the depth of heaven?* For the distances of the planets both from one another and from the fixed stars, laterally, or in the superficial compass of the heaven, are governed by their motions. But as I said before concerning the magnitude of the stars, that if an exact and measured magnitude is not to be had, we must take a comparative magnitude; so I say with respect to their distances; namely that if the distance (say from the earth to Saturn or Jupiter) cannot be exactly taken, yet let us make it certain that Saturn is higher than Jupiter. For neither is the interior system of the heaven, I mean the order of the planets in point of altitude, entirely without controversy; nor were the doctrines now prevalent believed in former times. And even now the question whether Mercury or Venus be the higher, is still pending. Now distances are discovered either from parallaxes, or eclipses, or calculations of motions, or differences in apparent magnitude. And other aids are to be provided for the determination of this, which may be devised by human industry. The thicknesses or depths of the spheres also have relation to distances.

THEORY OF THE HEAVEN.

THEORY OF THE HEAVEN.

SEEING then that there are such difficulties on all sides, we must be content if something be asserted that is not harsh. I will myself therefore construct a Theory of the Universe, according to the measure of the history as yet known to us; keeping my judgment however in all points free, for the time when history, and by means of history my inductive philosophy, shall have been further advanced. Wherein I will first propound some things respecting the matter of the heavenly bodies, whereby their motion and construction may be better understood; and then I will bring forward my thoughts and views concerning the motion itself, which is now the principal question. It seems then that nature has in the distribution of matter separated fine bodies from gross; and assigned the globe of the earth to the gross, and the whole space from the surface of the earth and waters to the very extremities of the heaven, to the fine or pneumatic, as the two primary classes of things, in proportions not equal indeed, but suitable. And this is the natural and proper collocation of things, nor is it confounded either by water hanging in the clouds or wind pent within the earth. Now this distinction of fine or pneumatic and gross or tangible, is quite primordial, and the

one which is most employed in the system of the universe. And it is derived from that condition of things which is of all the simplest, namely the quantity and paucity of matter in proportion to bulk. The pneumatic bodies which are found here with us (I speak of such as exist simple and perfect, not compound and imperfectly mixed), are those two, Air and Flame. And these are to be regarded as bodies altogether heterogeneous; not as is commonly imagined, that flame is only air on fire. To these correspond, in the upper world, the ethereal and the starry nature; as in the lower, water and oil; and lower still, mercury and sulphur; and generally, crude bodies and fat bodies, or in other words, bodies which abhor and bodies which conceive flame (salts being of a compound nature, consisting at once of crude and inflammable parts). Now for these two great families of things, the Airy and the Flamy; we have to inquire upon what conditions they have taken possession of by far the greatest part of the universe, and what office they have in the system. In the air next the earth, flame only lives for a moment, and at once perishes. But when the air begins to be cleared of the exhalations of the earth and well rarefied, the nature of flame makes divers trials and experiments to attain consistency therein, and sometimes acquires a certain duration, not by succession as with us, but in identity; as happens for a time in some of the lower comets, which are of a kind of middle nature between successive and consistent flame; it does not however become fixed or constant, till we come to the body of the Moon. There flame ceases to be extinguishable, and in some way or other supports itself; but yet such flame is weak and

without vigour, having little radiation, and being neither vivid in its own nature, nor much excited by the contrary nature. Neither is it pure and entire, but spotted and crossed by the substance of ether (such as it exists there), which mixes with it. Even in the region of Mercury flame is not very happily placed, seeing that by uniting together it makes but a little planet; and that with a great perturbation, variety, and fluctuation of motions, like *ignis fatuus*, labouring and struggling, and not bearing to be separated from the protection of the sun except for a little distance. When we come to the region of Venus, the flamy nature begins to grow stronger and brighter, and to collect itself into a globe of considerable size; yet one which itself also waits on the sun and cannot bear to be far away from him. In the region of the Sun, flame is as it were on its throne, midway between the flames of the planets, stronger likewise and more vibrating than the flames of the fixed stars, by reason of the greater reaction, and exceeding intensity of union. In the region of Mars flame appears even robust; acknowledging the vicinity of the sun by its redness, but now independent, and bearing to be separated from the sun by the whole diameter of the heavens. In the region of Jupiter flame gradually ceasing to be contentious, seems calmer and whiter, not so much from its own nature (as the star Venus is, being more fiery), but from the surrounding nature being less irritated and exasperated; in which region it is probable, according to the discovery of Galileo, that the heaven begins to be set with stars, though stars invisible from their smallness. But in the region of Saturn, the flamy nature appears again to grow somewhat feeble and dull, as being both further

removed from the support of the sun, and exhausted by the proximity of the starry heaven. Last of all, the flamy and sidereal nature, victorious over the ethereal, produces the starry heaven, which is compounded of the ethereal and sidereal nature (as the globe of the earth is compounded of land and water) variously diffused, yet with the ethereal substance so converted, wrought, and assimilated, as to be completely patient and obedient to the sidereal. Thus we have between the earth and the summits of heaven three general regions, and as it were three stages, in respect of the flamy nature; the region of the extinction of flame, the region of its union, and the region of its dispersion. Now to argue of contiguity and continuity in the case of soft bodies and fluids would be vulgar. But it must be understood, that it is the way of nature to proceed a certain distance by gradations, and then suddenly by jumps; and to alternate this process; otherwise there could be no structural fabric, if all changes proceeded by insensible gradations. For how great a leap it is (in respect of expansion of matter) from earth and water to air, even the grossest and most nebulous! And yet these bodies so different in nature are in place and surface joined together, without any medium or interval. Nor is it a less leap (in respect of substantial nature) from the region of the air to the region of the moon: an immense leap again from the heaven of the moon to the starry heaven. Therefore if continuity and contiguity be understood with reference not to the manner of connexion, but to the diversity of the bodies connected, these three regions which I have mentioned may be regarded as being in their boundaries only contiguous. But now we must examine clearly and perspicuously

what and what kind of points this theory of mine on the substances of the system affirms, and what and what kind it denies; that it may the more easily be either maintained or overthrown. It denies the common theory, that *flame is air on fire;* affirming that these two bodies, air and flame, are completely heterogeneous, like water and oil, sulphur and mercury. It denies Gilbert's doctrine of *a collective vacuum between the scattered globes;* affirming that space is filled with either an airy or a flamy nature. It denies that *the moon is either a watery or a dense or a solid body;* affirming that it is of a flamy nature, though slow and weak, as being the first rudiment and last sediment of celestial flame; flame admitting (as regards density), no less than air and liquids, of innumerable degrees. It affirms that *flame, in its true place and left to itself, is fixed and constant,* no less than air and water; and that it is not a thing momentary, and preserved in its mass only by succession through renovation and aliment, as it is here with us. It affirms that *flame has a nature apt to unite and gather into globes,* like the nature of earth; not like that of air and water, which are collected in the circles and interstices of globes, but never into entire globes. It affirms that *the same flamy nature in its own place (that is the starry heaven) is scattered about in infinite clusters,* yet in such sort that the dualism of ether and star is still maintained, and flame does not continue into the perfect empyrean. It affirms that *the stars are real flames,* but that the actions of flame in heavenly bodies are in no way to be applied to the actions of our flame, most of which operate only by accident. It affirms that *the interstellar ether and the stars bear to each other the relations of air and flame, but sublimed and rectified.* Regard-

ing the Substance then of the System of the Universe, such are the thoughts which occur to me. I must now speak of the Motions of the Heavenly Bodies, with reference to which I have brought these things forward. It seems reasonable to suppose that rest is not excluded from nature, as regards any whole (for I am not now talking of particles). This (discarding logical and mathematical subtleties) appears most clearly from the fact, that the speed and velocities of the celestial motions relax themselves gradually, as if about to end in something immovable; and that even the celestial bodies have a share of rest in respect of the poles; and that if immobility be excluded, the system is dissolved and dispersed. Now if there be any collection and mass of the immovable nature, we need not look further to show that this mass is the globe of the earth. For close and strict compaction of matter induces a disposition towards motion torpid and averse; as on the other hand free explication of it induces a disposition prompt and apt. Nor was it ill done by Telesius (who revived the philosophy and discussions of Parmenides in his book on the original source of cold) to introduce into nature, not indeed coessentiality and conjugation (which he would have), but yet affinity and conspiration; making heat, light, tenuity, and mobility to be allied on one part; cold, darkness, density, and immobility on the opposite; and placing the seat of the first set in the heaven, of the second in the earth. But if *rest and immobility* be admitted, it seems that *motion without limit and perfect mobility* should likewise be admitted, especially in opposite natures. Now this motion is the motion of rotation, such as is generally found in the celestial bodies. For mo-

tion in a circle has no limit, and seems to proceed from an appetite of the body, which moves merely for the sake of moving and following itself and seeking its own embraces, and exciting and enjoying its own nature, and performing its own operation; whereas contrariwise motion in a straight line seems like a journey to an end, as seeking both to reach the limit where it may cease and rest, and to attain some object and then discontinue its motion. We must see therefore how this motion of rotation, which is the true and perennial motion, and commonly considered peculiar to the heavenly bodies, acquits itself, and by what control it spurs and bridles itself, and generally how it is affected; in the explanation of which things I shall not stand upon that piece of mathematical elegance, the reduction of motions to perfect circles, either eccentric or concentric, or that high speech, that the earth in comparison to heaven is a point and not a quantity, or many other fictitious inventions of astronomers; but remit them to calculations and tables. But first I will make a division of the motions of the heavenly bodies. *Some are cosmical, others mutual.* Those I call *cosmical*, which celestial bodies assume by consent, not only of the heavens, but likewise of the universe; those *mutual*, in which one celestial body depends on another. And this is a true and necessary division. The earth then being stationary (for that I now think the truer opinion), it is manifest that the heaven revolves in a diurnal motion, the measure whereof is the space of twenty-four hours or thereabouts, the direction from east to west, the axis of revolution certain points (which they call poles) north and south. For the heavens do not travel on movable poles, nor are there any other points than those I have

mentioned. And this motion appears to be truly cosmical, and therefore one and the same; except in so far as it admits both diminutions and deviations; according to which diminutions and deviations this motion strikes through the whole universe of things movable, and penetrates from the starry heaven to the bowels and depths of the earth; not forcing them along with violence or vexation, but by a perpetual consent. And this motion is in the starry heaven perfect and entire, as well in just measure of time, as in exact restitution of place. But the lower down we come, the more imperfect is this motion, in respect of slowness, and in respect likewise of deviation from circular motion. And first I must speak of the slowness separately. I say then that the diurnal motion of Saturn is too slow to allow of its completing the circle or coming back to the same place within twenty-four hours; but that the starry heaven moves faster, and outstrips Saturn each day by a distance which multiplied by the number of days in thirty years makes up the whole circuit of the heaven. So also with regard to the other planets, according to the diversity of their several periods; so that the diurnal motion of the starry heaven (speaking of the period only, without reference to the magnitude of the circle) is about one hour quicker than the diurnal motion of the moon. For if the moon completed its course in twenty-four days, it would be quicker by an hour exactly. Therefore that motion of opposition and resistance from west to east which they talk of, and which is attributed to the planets as peculiar to them, is not a real motion, but only in appearance, owing to the starry heaven advancing faster to the west, and so leaving the planets behind towards the east.

Upon which supposition, it is manifest that the velocity of this cosmical motion decreases in regular order as it descends, so that the nearer every planet approaches the earth the slower it moves; whereas the received opinion disturbs and inverts the order; and by attributing a peculiar motion to the planets falls into the absurdity of supposing that the nearer the planets approach the earth (which is the seat of immobility) the quicker they move; a thing which astronomers idly and unsuccessfully endeavour to account for by supposing a remission of the violence of the *primum mobile*. And if it seem strange that in so great a space as lies between the starry heaven and the moon this motion diminishes so little; namely less than one hour, which is a twenty-fourth part of the diurnal motion; it is to be remembered that the nearer a planet is to the earth the smaller is the circle of its revolution; so that if we add the decrease in the magnitude of the circle to the decrease in the time of revolution, we shall see that the motion is diminished very considerably. Thus far I have spoken of velocity separately; as if the planets (placed, for instance, under the equinoctial, or any of the parallels) were only outrun by the starry heaven and by one another, but yet in the same circle. For this would be simple leaving behind without obliquity of motion. But it is manifest that the planets not only move with unequal velocity, but do not return to the same point of the circle, deflecting to the north and south; the limits of which deflexion are the tropics; and to this deflexion it is that we owe the Oblique Circle and the Difference of Polarity; just as we owe to the inequality of velocity the motion of Resistance. But the nature of things does not stand in need of this

device, more than of the other; seeing that by adopting spiral lines (the supposition which comes nearest to the sense and the fact) the thing is accomplished, and those phenomena are saved. And (which is the chief point) these spirals are nothing else than defections from perfect circular motion, whereof the planets are impatient. For in proportion as substances degenerate in purity and freedom of development, so do their motions degenerate. Now it happens, that as in point of velocity the higher planets move faster, and the lower less fast; so also the higher planets make spirals more closely coincident and coming nearer to circles, the lower make spirals more disjoined and further apart. For continually as they descend they recede more and more both from that height of velocity and that perfection of circular motion, in regular order. Yet in this the planets agree (as being bodies that retain much of a common nature, though otherwise differing) that they have the same limits of deflexion. For neither does Saturn come back within the tropics, nor the moon go forth beyond the tropics (and yet with regard to the wandering of Venus there are certain traditions and observations not to be overlooked); but all the planets, whether the higher or lower, as soon as they reach the tropics, turn back and retrace their course, disliking the smaller spiral in which they would have to move if they approached nearer the poles; and shrinking from that loss of motion, as from the destruction of their nature. For however in the starry heaven both the stars near the poles and the stars about the equinoctial maintain their ranks and stations, one being kept in order by another, with a perfect and equable constancy; yet the planets seem to be of such a mixed

nature as not willingly to endure either a shorter circle or a larger. These views then concerning the celestial motions appear to me a little better than the carrying by force, the repugnance of motions, the different polarity of the zodiac, the inverted order of velocity, and the like; which have no manner of agreement with the nature of things, however they keep peace, such as it is, with the calculations. Neither were the better astronomers blind to these things; but being intent on their art, and foolishly attached to perfect circles, and catching at subtleties, and too servile to philosophy, they scorned to follow nature. But this imperious disposition of philosophers towards nature is worse even than the simplicity and credulity of the vulgar; if a man disdains a plain thing because it is plain. And yet a vast evil it is and of very wide extent, that the human wit, not being able to match nature, must needs put itself above nature. But now we must inquire whether that single and simple motion, in a circle and spiral, from east to west, on certain poles south and north, ends and terminates with the heaven, or extends likewise to things below. For it will not be open to us to invent here in the regions next us such things as they suppose in the heavens. If therefore in these regions also this motion be found, it will appear that in heaven likewise it is, under the conditions of a common or cosmical nature, such as we experience it. First then it is plain that it is not confined within the limits of heaven. But the demonstrations and evidences on this point I have fully treated in my "anticipation" concerning the ebb and flow of the sea;[1] to which men are therefore referred; and taking

[1] See p. 328. of this volume.

this for settled and concluded, I will proceed to the other motions of celestial bodies. These I have said are not cosmical, but mutual, or having relation one to another. There are four kinds of motions visible in heavenly bodies besides that which I have called cosmical, which is the diurnal motion by spirals within the tropics. For the stars either rise higher and again sink lower, so as to be further off and nearer the earth; or they turn and wind from side to side of the zodiac, running out more to the south or more to the north, and forming what they call dragons; or they vary in velocity and likewise in direction of motion (for I put these two together), proceeding sometimes quicker, sometimes slower, sometimes in progression, sometimes in regression, sometimes likewise stopping and remaining stationary; or they are attached and circumscribed at a greater or less distance from the sun. The causes and natures of these motions I will only give in general and by heads; for this the plan of my work here demands. But to pave and open the way for this, I must say without reserve what I think with regard to certain philosophical doctrines, as well as astronomical hypotheses, and likewise with regard to the observations of astronomers in various ages, upon which they build their art; all which appear to me full of error and confusion. There are some axioms then, or rather opinions, which being received by philosophers, transferred into astronomy, and unhappily believed, have corrupted the art. Of these my rejection and judgment will be simple: for I have no time to spend in confutations. The first is, that all things above the moon inclusive are incorruptible, and not subject to new generations or changes of any kind. Of this I

have spoken elsewhere, as being a superstition and a vanity. But it is the fountain from which springs that vast evil, that upon every anomaly astronomers frame new and (as they think) corrected theories, and often apply to things that are as it were fortuitous causes eternal and invariable. The second is, that the heaven (as consisting of a fifth essence, and of no elementary substance) admits not of those turbulent actions of compression, relaxation, repulsion, submission, and the like, that seem to be produced by a certain hardness and softness of bodies, which are regarded as elementary qualities. But this assertion is an insolent and licentious repudiation of fact and sense. For wherever a natural body is placed, there also is resistance, and that in proportion to the body. And wherever there are natural bodies and local motion, there is either repulsion, or yielding, or division; for these things above mentioned, namely, compression, relaxation, repulsion, yielding, with many others, are universal passions of matter everywhere. And yet from this fountain has flowed that multiplication of circles complicated at pleasure, which they will nevertheless have to be so adapted to each other, and to move and turn with such smoothness and slipperiness one within the other, that there is no obstruction at all, no fluctuation; all which are plainly fanciful, and trample upon the nature of things. The third is, that all natural bodies have their own proper motions; and if any be found to have more than one, that all the rest come from elsewhere, and from some separate moving body. Than which nothing falser can be devised, seeing all bodies by the manifold consent of things are endued likewise with many motions, some ruling, some obeying, and

some also lying dormant unless exerted; and proper motions of things there are none, except exact measures and modes of common motions. Hence again has come forth a separate *primum mobile*, and heavens above heavens, and a continuous chain of new structures, to meet the demands of such different motions. The fourth is, that all celestial motions are performed in perfect circles; a thing very cumbrous, which has produced for us those prodigies of eccentrics and epicycles; whereas if they had consulted nature, they would have found that while motion orderly and uniform is in a perfect circle, motion orderly but multiform, such as is found in many heavenly bodies, is in other lines; and deservedly does Gilbert laugh at this, saying that it is not probable nature would have formed wheels of one or two miles for instance in circuit, to carry a ball the size of a palm.[1] For it seems that the body of a planet is no bigger, as compared with those circles which they invent for it to move in. The fifth is, that the stars are parts of their own orb fixed as it were by a nail. But this is very evidently a conceit of those who deal with mathematics not with nature, and fixing all their attention on the motion of bodies entirely forget their substances. For that fixation is a particular affection of compact and consistent things, which keep firm hold by reason of the pressure of their parts. But it is quite inconceivable, if it be transferred to soft or liquid bodies. The sixth is, that a star is the denser part of its own orb; whereas the stars are neither parts, nor denser.[2] For they are not homogeneous with the air, differing only in degree, but they are quite heterogeneous and differ in substance; which

[1] Gilbert, Physiol. Nov. ii. 11.

[2] Cf. Arist. De Cœlo, ii. 7.

substance also is in respect of density rarer and more open than the ethereal. There are likewise many other opinions equally vain; but these will suffice for the present business. So much then for the doctrines of philosophy concerning celestial bodies. As for the hypotheses of astronomers, it is useless to refute them, because they are not themselves asserted as true, and they may be various and contrary one to the other, yet so as equally to save and adjust the phenomena. Let it then be arranged, if you will, between philosophy and astronomy, as by a convenient and legitimate compact, that astronomy shall prefer those hypotheses which are most suitable for compendious calculation, philosophy those which approach nearest the truth of nature; and that the hypotheses of astronomy shall not prejudice the truth of the thing, while the decisions of philosophy shall be such as are explicable on the phenomena of astronomy. And so much for hypotheses. But with respect to astronomical observations, which are assiduously accumulated, and are continually dropping like waters from the heaven, I would by all means have men beware, lest Æsop's pretty fable of the fly that sate on the pole of a chariot at the Olympic races and said "what a dust do I raise," be verified in them. For so it is that some small observation, and that disturbed sometimes by the instrument, sometimes by the eye, sometimes by the calculation, and which may be owing to some real change in the heaven, raises new heavens and new spheres and circles. Nor do I say this because I would have any relaxation of industry in observations and history, which I say should be sharpened and strengthened in all ways, but only that prudence and a perfect and settled maturity of judg-

ment may be employed in rejecting or altering hypotheses. Having therefore now opened the way, I will make a few general observations on the motions themselves. I have said that there are four kinds of greater motions in the heavens. *Motion in the depth of heaven*, upward or downward; *motion through the latitude of the zodiac*, deviating to south and north; *motion in the direction of the zodiac*, quick, slow, progressive, retrograde, and stationary; and *motion of elongation* from the sun. And let no one object that this second motion of latitude, or the dragons, might have been referred to that great cosmical motion, being an alternate inclination towards north and south; inasmuch as these spirals move in like manner from tropic to tropic; only that the cosmical motion is spiral simply, whereas the other is likewise sinuous and with much smaller intervals. For this has not escaped me. But the fact is, that the constant and perpetual motion of the sun in the ecliptic without latitude and dragons, which sun nevertheless has a common motion with the other planets in respect of spirals between the tropics, forbids me to agree with this opinion. We must therefore seek other sources both of this and of the three other motions. Such are the ideas with regard to the celestial motions which seem to me to have least inconvenience. Let us see then what they deny and what they affirm. They *deny* that the earth revolves. They *deny* that there are two motions in the heavenly bodies, one being from west to east; and *affirm* a difference in speed, one outstripping and leaving the other behind. They *deny* an oblique circle with a different position of its poles; and *affirm* spirals. They *deny* a separate *primum mobile*, and carriage by force; and *affirm* a

cosmical consent as the common bond of the system. They *affirm* that the diurnal motion is found not in the heaven only,[1] but also in the air, water, and even the exterior of the earth, in respect of its verticity. They *affirm* that this cosmical motion of flowing and rolling in fluids, becomes verticity and direction in solids, until it passes into pure immobility. They *deny* that the stars are fixed like knots in a board. They *deny* that eccentrics, epicycles, and such structures are real. They *affirm* that the magnetic motion, or that which brings bodies together, is active in the stars, whereby fire evokes and raises fire. They *affirm* that in the planetary heavens the bodies of the planets move and revolve with greater velocity than the rest of the heaven in which they are situated, which does indeed revolve but more slowly. They *affirm* that from this inequality come the fluctuations, waves, and reciprocations of the planetary ether, and from them a variety of motions. They *affirm* a necessity in the planets of revolving faster and slower, according as they are situated high or low in the heaven, and that by consent of the universe. But at the same time they *affirm* a dislike in the planets of preternatural velocity as well of the greater as of the lesser circle. They *affirm* a tendency to follow the sun, by reason of neediness of nature, in the weaker fires of Venus and Mercury; the rather, because Galileo has discovered certain small wandering stars attendant upon Jupiter. These then are the things I see, standing as I do on the threshold of natural history and philosophy; and it may be that the

[1] *Motum diurnum inveniri non in cœlo, sed et in aëre, aquis, etiam extimis terræ, quoad verticitatem.* So the sentence stands in the original. But it seems that *tantum* or some equivalent word has dropped out. — *J. S.*

deeper any man has gone into natural history the more he will approve them. Nevertheless I repeat once more that I do not mean to bind myself to these; for in them as in other things I am certain of my way, but not certain of my position. Meanwhile, I have introduced them by way of interlude, lest it be thought that it is from vacillation of judgment or inability to affirm that I prefer negative questions. I will preserve therefore, even as the heavenly bodies themselves do (since it is of them I am discoursing), a variable constancy.

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